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THE EFFECT OF CUE LOCATION AND DRIVE LEVEL ON INCENTIVE PREFERENCES IN RATS

by

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B.A., University of Windsor, 1973

A Thesis

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ABSTRACT

Eight moderate (MOD) and eight highly water deprived (HI) albino rats were trained in one of three simultaneous two-choice discrimination tasks: floor texture and goal door brightness relevant (RRC task), texture relevant and brightness irrelevant (RTC), or brightness relevant and texture irrelevant (RBC). The position of the incentives, a 20% sucrose solution and water, was constant. The animals were tested for position preference when both goal positions were made positive. Rate of learning was faster in the RRC task. MOD animals in each discrimination task ran faster to the 20% sucrose solution than to water during the original discrimination training. HI animals in the RTC task also displayed similar running speed differences. No other HI-task group showed differential running speeds to the incentive positions. Only MOD animals in the RBC and RTC-task groups made more errors to the 0% incentive than to the 20% incentive position when S+ denoted the availability of each incentive. Except for the HI-RRC group, all task-drive groups showed a preference for the 20% sucrose position. MOD animals displayed total preference for the high incentive while the HI-RTC animals did choose the water side on some trials. The results were discussed in terms of the effect of span of attention and cue salience on the acquisition incentive-position associations.

PREFACE

This research was conducted under the supervision of Dr. J. S. Cohen. His patience and guidance assisted in making the thesis a reality and deserves the sincere appreciation of the author.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER I

Introduction

Statement of the Problem

Several studies have found that thirsty rats do not show as great a preference for sucrose concentrations over water as hungry or satiated animals. Experience with sucrose during a continuous presentation, however, has been observed to increase the preference for sucrose in the water deprived rat.

Beck and Nash (1969) have advanced an approach arousal theory to explain such findings. Preference threshold studies for sucrose have shown that the sucrose acceptance function of the water deprived rat is shallower than for the non-deprived or food deprived rat. Water is highly acceptable to thirsty rats, thus raising the differential preference threshold for water close to the level of approach arousal for sucrose. However, if the solutions are continuously available, the sucrose might provide a more or less continuous stimulation of slightly greater approach arousal. Such conditions would permit highly water deprived animals to orient more to the higher sucrose solution. Most of the studies employing intermittent presentations of various sucrose concentrations in consummatory and instrumental response behavior have supported Beck and Nash's (1969) approach arousal theory. Thus thirsty rats either increase

activity for lower concentrations or display indifferent behavior.

When different incentives are presented simultaneously, however, the effects of drive level are less clear. Beck and Bidwell (in press) found that thirsty rats failed to display any consistant choice for sucrose or water during free choice trials. Cohen and Oostendorp (unpublished manuscript), on the other hand found that thirsty rats displayed a greater preference for sucrose than for water during the choice trials. Running speed was greater to successively presented sucrose solution for the moderately deprived animals, but no difference in running speed for the two successfully presented solutions was found in the highly water deprived rats. The latter findings suggest that different mediating mechanisms are involved in choice behavior and running speed.

One of the basic differences between the latter two studies may have been the lack of any discriminative cue on positions in Beck and Bidwell's research. Cohen and Oostendorp trained their rats always to approach a black door on either the high or low incentive side. This training could have allowed both drive groups to establish incentive-position associations. Running speed may have been more a function of immediate anticipatory goal responses.

In several incentive motivation theories the fractional anticipatory goal response has been hypothesized to play an important role in the transfer of motivational properties onto the running response. It has also been suggested that

the fractional anticipatory response becomes classically conditioned to cues at the beginning of the runway.

The purpose of the present study was to explore the effect of location of the discriminative cue on running speed and free choice behavior to incentives in highly and moderately water deprived animals. Location of S+ closer to the starting area was expected to enhance differential anticipatory responding in highly deprived animals and thus increase running speed to the higher incentive solution. The degree to which differential speeds and choice behavior covary might suggest possible interactions between anticipatory incentive responding and incentive-position acquisition.

Background and related research

Variation in incentive magnitude has been shown to affect performance systematically in relation to the amount of reward. Studies concerned with the quantitative variations of food (e.g. Crespi, 1942; Reynolds, 1949; and Zeaman, 1949) have shown that increase in amount of reinforcement results in a greater reaction potential of the instrumental response.

Guttman (1953) was the first to study the effect of variation of another reinforcing object, sucrose concentrations. The initial slopes of rate of responding in a lever-depressing situation were positively related to the concentration of sucrose. In a second experiment Guttman (1954) compared rate of responding to different concentrations of

two different reinforcing agents, sucrose and glucose. It was found that the sweeter substance, sucrose, produced a higher rate of responding.

Spence (1956) incorporated the latter findings into his incentive motivation theory. According to his theory differences in concentration of a reinforcing agent elicit consummatory responses of different vigor. It was hypothesized that stimulus cues in the goal box and from the alley just preceding the goal box become conditioned to consummatory goal responses (R_g). Through generalization the stimulus cues at earlier points in the runway are also assumed to acquire the capacity to elicit R_g. As earlier hypothesized by Hull (1943) some elements of R_g are in conflict with the instrumental response. Therefore, only the non-competitional elements become conditioned to the stimulus cues at the beginning of the response sequence. The latter part of R_g is represented by r_g, or the "fractional anticipatory goal response".

Hull (1952) and Spence (1956) further hypothesized that the fractional anticipatory responses give rise to stimuli (s_g). These stimuli evoke the response sequence in the organism, which will lead to the consummatory act. Hence, according to Hull (1932, 1952) the function of r_g is strictly that of a stimulus producing mechanism. Spence (1956), however, assumed that the s_g also becomes part of the stimulus complex in the alley and thus should become conditioned to the instrumental response. Furthermore, the association

of this interoceptive cue (s_g) to r_g results in the $r_g - s_g$ mechanism, which has motivational properties that vary with the magnitude or vigor of the consummatory response.

A limited number of studies have tested Spence's theory of incentive motivational properties of the $r_g - s_g$ mechanism. Lewis, Butler, and Diamond (1958) manipulated the fractional anticipatory goal response directly by administration of two different drugs. One group of rats received a mild anesthetic, which would decrease the fractional anticipatory response of salivation. The other group received a drug which increased salivation. Running speed measures indicated that the stimulating drug increased performance, relative to the anesthetic drug. A later study (Lewis & McIntire, 1959) provided evidence that the drugs only affected the fractional anticipatory response and not general motor activity. The results can thus be interpreted as providing evidence for the incentive motivational properties of the $r_g - s_g$ mechanism.

The assumption of generalization of goal box cues to earlier points of the apparatus was studied by Swift and Wike (1958). The results supported Spence's hypothesis in that the animals which obtained reinforcement in a goal box similar to the rest of the runway showed a faster running speed, than animals trained with a dissimilar goal box. However, Seward, Jones, and Summers (1960) demonstrated that a response to the goal box itself can be learned, carried forward in the response sequence and mediate r_g, even

if the goal box is dissimilar to the runway. Similarly, Gonzalez and Diamond (1960) found no support for Spence's generalization theory of cues. The results showed that consistency of goal box cues had more impact then similarity of goal box cues to runway cues.

It can be concluded from the latter experiments that the r_g becomes conditioned to the external stimuli at the beginning of the apparatus. The incentive motivational properties of the $r_g - s_g$ mechanism are considered to become established in a way similar to that of secondary reinforcement (Kimble, 1961). The vigor of the instrumental response is then a function of the strength of the consummatory response, which can be manipulated by varying the quantity or the quality of the reward.

Logan (1960) attributed the strength of the fractional anticipatory response to the distinctiveness of the feedback cues relative to the conditions of reinforcement. Thus, the incentive motivational property of r_g can only be established on the basis of the experience with the reward in that particular situation.

When studying the effect of variation of incentive on instrumental performance two methods can be employed: the absolute and the differential method (Pubols, 1960). In the absolute method seperate groups of animals are presented with only one of the various incentives. In the differential method the animals are rewarded with more than one incentive. In the first method the strength of the consummatory response

is directly related to and may determine the vigor of the instrumental response. In the latter method a discrimination of incentives on the basis of differential feedback cues, may affect the instrumental response. Logan (1960) demonstrated that if the various rewards are presented in random order the final response rate will be a compromise between the larger and the smaller r_g. However, if the amount of reward is associated with specific external cues, such as brightness, differential responding will occur. D'Amato (1955) trained rats on a successive discrimination problem in a runway such that the colour of the goal box was associated with the amount of reward. It was found that the animals ran faster for the larger than for the smaller reward. Similarly in incentive-shift experiments, in which the subjects received a second reinforcement after training with another, a direct shift in performance in relation to the amount of reinforcement was found (e.g. Pereboom, 1957; Dufort & Kimble, 1956).

In the above description of incentive motivation research the strength of the instrumental response has been discussed usually in terms of the incentive value of the reward. The latter, however, has been hypothesized to interact multiplicatively with drive (Hull, 1943). A multiplicative effect of incentive and drive on response strength implies that the difference in the effectiveness of two drive levels should be greater for greater incentive magnitudes. However, Spence (1956) maintained that incentive

motivation (K) adds to drive (D) effect. This position predicts that the difference in effectiveness of two drive levels will be equal for all incentive magnitudes. In a review of relevant findings on this controversy, Black (1965) pointed out that when the lower values of D and K are zero the multiplicative theory holds true, but D and K are additive when nonzero values are used.

In Hull's system (1952) it has furthermore been postulated that the interoceptive cues of the r_g - s_g mechanism are drive specific. Thus, only rewards with a reinforcing value for the relevant drive will increase the habit strength and subsequently the reaction potential. For example different types of deprivation (water vs food) have been shown to have different effects on responding to different levels of sucrose solutions. Most studies dealing with food deprivation report a steep direct concentration-response function. But water deprivation has been shown to produce a very shallow direct function under most test conditions.

Sucrose incentive and food deprivation

Most of the studies using food deprived animals have supported Spence's (1956) and Logan's (1960) incentive motivation theory. Findings of studies which used the absolute method showed an increase in performance as a function of sucrose concentration (Homzie & Ross, 1962; and Ison & Glass, 1968). However, the difference in performance for various sucrose concentrations in independent nondeprived groups did not reach significance (Young & Shuford, 1955). It was

also found that under certain conditions asymptotic rates of responding to very high concentrations occurred sooner, but at a lower rate, than asymptotes to some of the lower concentrations. Guttman (1953) attributed such a finding to uncontrolled consummatory behavior which competed with the bar pressing task.

Food deprived animals presented with various sucrose concentrations simultaneously (Owings & Lockard, 1968) or successively (Dufort & Kimble, 1956) have consistently shown behavioral preference for the higher concentrations. Carpenter (1958) observed largest intake of the highest concentration (30%) during a 48 hour simultaneous presentation of 8 different solutions. Number of bar presses for sucrose reinforcement was found to be proportional to their concentrations if presented in ascending order, but not for the descending series (Tombaugh & Marx, 1965). Furthermore, number of bar presses during the nonreinforced trials which followed ascending, or descending series, was found to be greater if the terminal reinforcement was the higher sucrose concentration. Similar results occurred for the control animals which received constant sucrose concentration followed by nonreinforced trials. Flaherty, Riley and Spear (1973) found running speed to be a direct function of concentration of sucrose reinforcement. The effect was more pronounced for the group trained with differential reinforcement than for the independent groups.

Wetzel (1959) found that hungry rats which had

experienced a 20% sucrose solution would learn a discrimination task faster than the animals which had not received the sucrose during pretraining. It can, therefore, be assumed that experience with the reinforcement enhanced the motivational properties of the feedback cues of the consummatory response. Subsequently according to Logan (1960) the motivational properties would be carried over onto the running response by mediation of the $r_g - s_g$ mechanism. However, no differential motivation was observed for satiated animals. Similar results were reported by Smith and Duffy (1957). The latter findings seem to indicate that drive and sucrose reinforcement not only affects performance but also the rate of learning.

Studies employing sucrose incentives and food deprivation have reported additive as well as multiplicative interaction effects of drive and incentive. Smith and Kinney (1956) presented a satiated and a food deprived group (23 hr.) with water and a 20% sucrose concentration as reinforcement. Only the food deprived animals that received water showed lower performance than the other three groups. Stabler (1962) trained independent groups under a low (4 hr.) or high (20 hr.) food deprivation schedule in a straight alley. Reinforcement was one of three levels of sucrose concentration, 8%, 16%, or 32%. Only the high group trained with 32% sucrose incentive differed in asymptotic running speed from the high group which received the 8% solution. However, no other differences between groups were observed. Thus, Smith

and Kinney (1956) and Stabler (1962) both reported a multiplicative interaction of drive and incentive. However, the second study did not employ a true zero value of drive nor of incentive, and according to Black (1965), an additive effect might have resulted. On the other hand Brush, Goodrich, Teghtsoonian and Eisman (1961) reported that all high drive groups (23 hr. deprivation) ran faster than the low drive (food ad lib., except for day prior to acquisition). For both drive levels performance increased in direct relationship with concentration of sucrose (6%, 14%, and 32%). Thus incentive was found to add to the drive effect in support of Spence's (1956) hypothesis. Brush et al.'s (1961) findings also were in agreement with Black's (1965) assumption since all the values of incentive and drive were above zero. However, Beck and Austin (1973) found that an interaction also can occur when there is a wide incentive separation, e.g. 3% vs 12%, or 3% vs 24% sucrose solutions. Thus the difference in running speed between the nondeprived and food deprived group (23 hr.) was greater for the higher than for the lower incentive. However, when the incentive difference was small, 3% vs 6%, both drive groups did not show much difference in running speed between the incentives. Higher drive did increase speed over both incentives in a constant additive manner. These results support Logan's (1960) contention that consummatory feedback cues are important in the mediation of differential response strength by means of the $r_g - s_g$ mechanism.

Water deprivation and sucrose incentives

Beck (1963) was one of the first investigators to determine the effect of sucrose concentrations on performance in thirsty rats. The animals were deprived of water for 22.5 hours and received one of the three sucrose reinforcements (4%, 12%, or 36%) for a bar pressing response. The results did not show differential response levels to the different sucrose concentrations. To test the hypothesis that the primary drive of thirst had influenced the results, a stomach load of either saline or water was administered to the rats prior to testing. Both loads depressed responding. Increased water loads increased preference for higher sucrose concentrations. Increased saline loads, however, decreased preference for higher sucrose concentrations. It was concluded that highly thirsty rats respond indiscriminately for water or different sucrose solutions. In a choice situation of six different sucrose solutions ranging from 0% to 32%, Owings and Lockard (1968) found that highly water deprived animals (72 hours) preferred water over sucrose if food was available, but preferred 4% sucrose solution when food was not available. The latter findings suggested the need-reduction value of sucrose in situations of food deprivation. However, during subsequent hours a shift of preference for higher concentrations was observed for the water deprived animals. Beck and Ellis (1966) reported that water is preferred in rats under extreme thirst, and when the other choice is a very high concentration of sucrose

solution (e.g. 54%). Similarly Rosen and Jacobs (1968) found that number of bar presses in water deprived animals would be lowest for a 32% sucrose solution if the animals received this solution in the first interval (15 min.) of a series of sucrose solutions (4%, 8%, 16%, or 32%). The lower concentrations yielded initially higher instrumental response output. The findings indicate that thirsty rats may be more highly motivated to reduce dehydration than to choose sweeter solutions.

In 1969 Beck and Nash (experiment 2) trained and tested rats under 23.5 hours water deprivation for choice behavior of 0% vs 6% sucrose solutions. On the first 2 days the erratic behavior was found for the first 2 minutes. Over the following 18 minutes period a reliable preference for the 6% solution developed. On the following test days a preference for the sucrose solution was already apparent in the second minute. The latter finding was interpreted to indicate that experience with sucrose is sufficient for the water deprived rat to initiate a sucrose preference over water. According to Beck and Nash (1969), these results suggested that the approach arousal function of sucrose is flatter for the water deprived rat than for the food deprived rat. Thus sucrose preference with water deprived animals could only be shown under optimal test conditions of free choice behavior. The latter conclusion was also partly based on a study by Beck, Self and Carter (1965), in which water deprived rats did show a sucrose preference threshold (1.16%).

However, nondeprived rats were found to have a less shallow threshold (.43%). Campbell (1965) found that food deprived rats demonstrated an even lower threshold of .14%. On basis of the evidence of such a small threshold by even highly water deprived rats, Beck and Nash (1969), maintained that the difference in capacity of different sucrose concentrations to arouse approach behavior is different under thirst, but less so than under hunger. The latter is due to the fact that under high thirst drive the incentive value of water increases nearly to the level of sucrose concentrations.

Beck and Nash (1969) further hypothesized that the differential approach arousal value of sucrose concentration would decay as a function of time after the solution was removed. However, during continuous availability of the solutions such a decay would not occur and subsequently differential approach arousal would be exhibited by the water deprived rat just as well as by the food deprived rat. The latter assumption was tested by Beck, Nash, Viernstein, and Gordon (1972). The results supported this proposition since, as the duration of the preference test increased from 10 sec. to 60 sec. per min., sucrose preference increased from indifference to a reliable preference in the water deprived animals (water vs 6% or 12%). It was concluded that during continuous availability and consumption of the sucrose solution, arousal decay is prohibited. But when the concentration is removed arousal decay is complete within 50 sec. for water deprived rats (Beck, Nash, Viernstein & Gordon,

1972). The finding that the hungry animals also showed a less marked preference decline with shorter availability of the solution confirmed the arousal decay hypothesis.

By giving water deprived rats a stomach load of water before a one-lick preference test of water vs a 7.4% sucrose solution, Cohen and Tokieda (1972) reversed the preference for water over sucrose solution to a preference for sucrose over water. According to Cohen and Tokieda (1972) the water deprived rat's preference for water was related to its dehydrated condition. In terms of Beck's theory the high thirst drive resulted in very shallow differential approach arousal in the one drop test. The water load decreased the incentive value of water and subsequently increased the differential incentive motivation between the 7.4% sucrose solution and water.

In a single solution test of several sweet solutions (sucrose, glucose, and sodium saccarine) Ernits and Corbit (1973) found that taste influenced what and how much animals drink. Water deprivation added a small increment to the already high intakes of sweet solutions seen under non-deprived conditions. The latter study replicated findings from the investigation by Teitelbaum and Epstein (1963) on the hypothalamic regulations of intake. In the case of intake regulation dysfunction taste and smell were found to be motivating stimuli in intake regulation.

While the above studies required a consummatory response, Beck and Bidwell (in press) used a locomotor

approach response measure. Highly water deprived (23.5 hr.) and food deprived (23 hr.) rats received free and forced trials in a T-maze with water and 8% sucrose solution in a constant position. All animals were allowed 3 drops of solution for reinforcement. Hungry rats developed a 100% preference for the sucrose while thirsty rats showed no preference. It was concluded that the incentive values of sucrose and water under such limited availability had been equalized to a point where the test procedure was no longer sensitive to incentive motivation differences for the water deprived animals.

In contrast to the above study, Cohen and Oostendorp (unpublished manuscript) found that water deprived (23.5 hr.) rats preferred sucrose over water. Although the preference for the sucrose solution was more pronounced for the moderately (18 hr. - MOD) than for the highly (23.5 hr. - HI) water deprived rats, the results seemed to be the first to report a sucrose preference in a condition with short (10 sec.) intermittent incentive presentations. In this study, animals learned a brightness discrimination in a two choice situation with position of S+ correllated with incentive. Position of each incentive (water vs 20% sucrose solution) was kept constant. After acquiring the discrimination, animals were tested for their incentive position trials in a series of free choice trials. S+ was placed at both positions. MOD animals committed more errors and ran more slowly to S+ when it was at the water than at the 20% sucrose solution

position. HI animals did not display differential error or running speed behavior to the incentives. Animals in both drive groups, however, preferred the 20% incentive during the free choice trials. These results suggested that errors and to a greater extent speed indicated differential approach arousal independent of learned incentive position associations. Furthermore, examination of response topographies and error density in both groups also suggested the existence of different anticipatory incentive response tendencies. MOD animals appeared to react differentially to S+ based on its position. HI animals either chose the last reinforced position or chose the correct S+ as it approached the positions. The position of the discriminative cue close to the goal area may have thus affected the development of anticipatory incentive responses. Under high drive conditions, high arousal appeared to have prevented the choice of S+ until the animal was close to the discriminative stimuli and thus prevented anticipatory incentive position responses. MOD animals, however, appeared to make their choices of S+ further away from the discriminative stimuli. Thus they made a position response earlier and could thus more easily display differential anticipatory incentive responses. Based on this interpretation of speed differences between drive level group, discriminative cue placement should affect the development of anticipatory responding. If S+ occurred spatially closer to the starting point of the locomotor approach behavior, HI drive animals would also

be expected to display similar differential speed and possibly error responses to different incentives. That is HI animals should also show greater errors and slower speeds to the water incentives as denoted by a chosen S+.

The present study was designed to determine the effects of drive level and spatial location of S+ on running speed and position preference to incentives. For this purpose the effect of two spatially different dimensions, texture of decision chamber floor and brightness of goal box door, was compared. The texture cue was readily available at the starting point of the instrumental response, while the brightness cue was expected to cause shifting behavior as in the previous study by Cohen and Oostendorp (unpublished manuscript).

Groups of highly (HI - 23.5 hr.) and moderately (MOD - 18 hr.) water deprived animals were given series of random position discrimination trials. During this phase incentive presentation was successive. Thus, only one position on any one trial contained reinforcement, as indicated by the positive cue. Position of reinforcement, water and 20% sucrose concentration, was constant for each animal.

To compare the effect of the texture and brightness cues, groups of HI and MOD animals were trained in one of three discrimination tasks (RRC, RBC, RTC). The RRC groups were trained with the brightness and the texture dimension both relevant. In the other two tasks the animals received training with one dimension relevant and the other irrelevant.

For the RTC groups the floor texture cues were relevant. For the RBC, the brightness cues were relevant. During the acquisition phase the number of errors and running speed to both incentives were observed. Following three days of overtraining, a series of simultaneous incentive position test trials were presented. In these test trial both positions were denoted by the positive cue of the relevant dimensions. The irrelevant dimension in the RTC and RBC groups was presented at random on one position. Choice of position and running speed were recorded.

Specific hypotheses were based on the approach arousal theory (Beck & Nash, 1969), the $r_g - s_g$ mechanism in incentive motivation (Spence, 1956; Logan, 1960), and the findings in the study by Cohen and Oostendorp (unpublished manuscript). As in the latter study, the moderately thirsty animals were expected to display differential approach arousal. Thus, all MOD animals should make more errors and run more slowly to the water position than to the sucrose position. Differential approach arousal was expected to be enhanced in the HI animals that were presented with the discriminative cue at the beginning of the decision chamber. Thus, HI-RRG and RTC animals for which the floor texture cue was relevant were expected to show response patterns similar to those of MOD animals. This prediction is based on the $r_g - s_g$ concepts derived from Spence (1956) and Logan (1960). Brightness as the only relevant dimension was not expected to allow for the development of differential

incentive anticipatory goal responses in the HI animals. As in the earlier cited study HI-RBC animals should, therefore, not display differential error or running speed to either position during the discrimination phase. The present study would also determine the effect of redundant relevant cue presentation and drive level on the rate of acquisition of the discriminative successive incentive task.

During the test choice trials in the testing phase all animals were expected to show a very strong preference for sucrose as in the previous study by Cohen and Oostendorp (unpublished manuscript). Differences of running speed to the two incentive positions during the inter test trials were expected to show the same effects as during overtraining sessions for each drive-task group.

CHAPTER II

Method

Subjects

Forty-eight male albino rats (Wistar strain) obtained from the breeding colonies of Woodlyn Farms, Guelph, Ontario, were used in the study. They were approximately 85 days of age at commencement of pretraining. Four squads of 12 animals were run successively over a period of about 4 months. During the pretraining phase 5 animals failed to become habituated to the discrimination apparatus. They were substituted by animals from the same breeding stock in order to maintain groups of equal n.

Apparatus

A simultaneous two-choice discrimination box, measuring 79.0 x 46.0 x 30.0 cm. externally, was used (see Figure 1). The apparatus was constructed of 1.3 cm. thick plywood, and painted flat gray. The discrimination box was divided into a V-shaped decision chamber, 50.0 x 42.0 cm., and two goal chambers, 28.0 x 21.0 cm. Entry into the decision chamber was gained through a covered start-box, 18.0 x 7.5 x 12.5 cm., at floor level midway at the wall opposite the discriminanda. A manually operated clear plexiglass door could be lifted to expose the subject to the decision chamber. Access to the reinforcement in each of the goal chambers was through a doorway, 10.5 x 10.5 cm. Interchangeable doors,

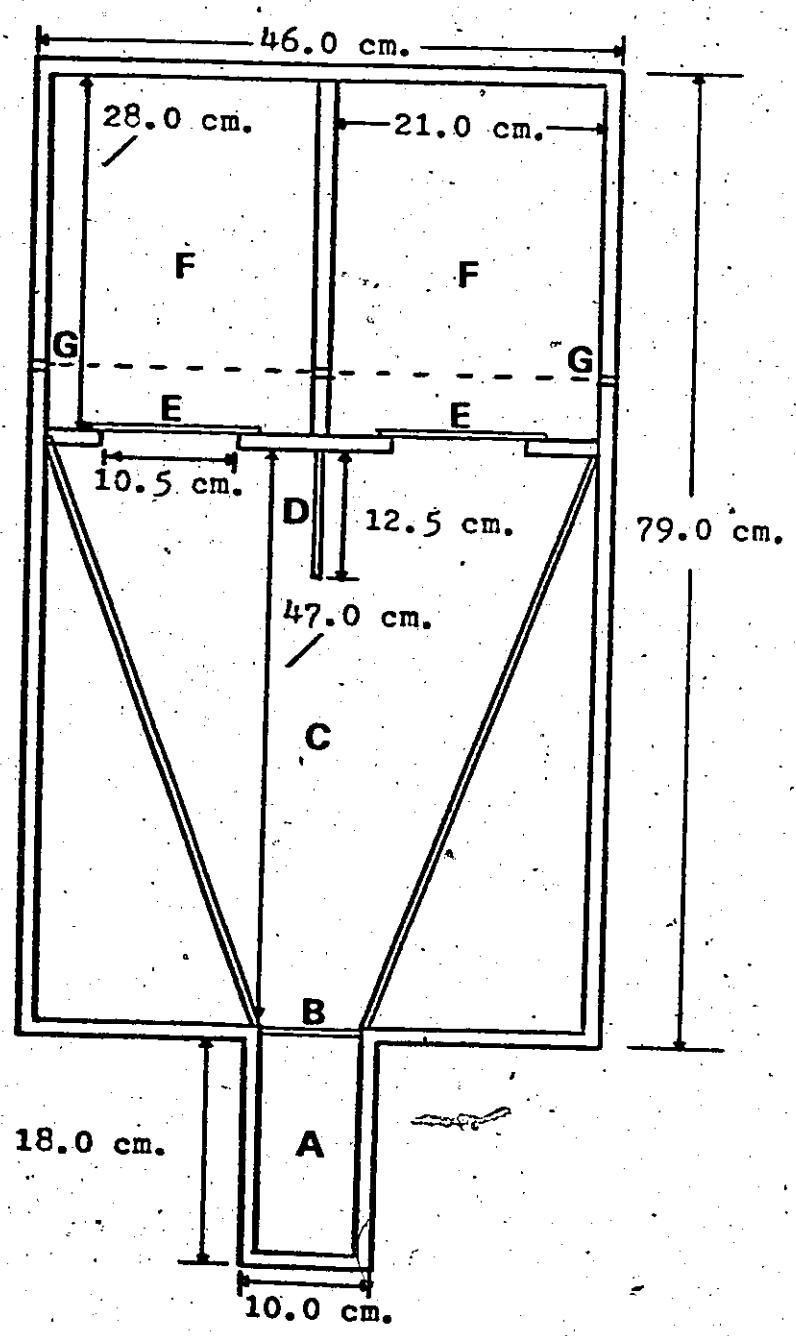

Figure 1. Floor Plan of Discrimination Box. After placement in the starting box (A) the guillotine door (B) is raised and the animal is allowed to enter the decision chamber (C). Opening of a goalbox door (E) breaks the photobeam (G) in the goal chamber (F). The approach areas to the goal chambers are seperated by a plexiglass divider (D).

0.5 cm. thick, could be attached behind each doorway. The doors could be locked from inside the goal chambers. Midway between the doorways a clear plexiglass divider extended 12.5 cm. from the wall to separate the approach areas of the two doorways. Throughout the study the only source of illunination was by a 100-Watt incandescent lamp situated above the start-box opening. The decision chamber received lighting in this way.

Running time was recorded (to the nearest 0.1 sec.) by a Standard Electric stopclock (LaFayette Company, Montreal), which was connected to a relay system. The opening of the guillotine door operated a microswitch which started the clock. When a photobeam, placed 4.0 cm. behind the doorways in the goal boxes, was broken by the rat the clock stopped.

For reinforcement 20%, 10% sucrose solutions (wt./vol.) and tapwater were used. Prior to running all solutions were warmed to room temperature. The bottles with the reinforcement were put from outside through a hole in the backwall of the goal chambers, in such a way that the drinking tube protruded 7.0 cm. from the floor.

In order to provide the animals with the appropriate floor texture, smooth (painted flat gray) or rough (strips of gray sandpaper on gray painted floor), interchangeable decision chamber floors were used. The sandpaper strips were 1.25 cm. wide and were seperated by 1.25 cm. smooth floor. The strips were parallel to the discrimination wall.

This texture stimulus occurred from the start-box opening to the discrimination doors.

Procedure

Taming. The animals were handled for 5 min. a day for 5 days, while on food (Purina Rat Chow) and water ad lib. The animals were housed in individual cages.

Pretraining. The 13 day pretraining procedure was designed to habituate the animals to the apparatus and to shape them to open a goal box door for reinforcement. All animals were maintained on a water deprivation schedule of 21 hours per 24 hours. The reinforcement liquid was a 10% sucrose solution. Previous studies (e.g. Cohen & Telegdy, 1970) found that these deprivation and incentive levels were most adequate for training of the instrumental task, without debilitating the animal. The levels were also intermediate to the deprivation and incentive levels which were used in the discrimination training.

Days 1 - 3. While being held by the experimenter each animal learned to lick from a 10% sucrose solution out of a drinking bottle which was placed on a wooden holder. Repitition of the procedure 3 times daily (with a total time of 5 min.) was done to allow the animal to associate handling with reinforcement.

Days 4 - 5. The animal was given 5 continuous minutes of discrimination box exploration. No doors were presented. The animal was allowed to drink freely from the 10% sucrose solution which was available in both goal chambers.

Throughout the pretraining phase a smooth floor was used in the decision chamber.

Days 6 - 7. Two gray doors were placed in the doorways. On each trial the rat was required to push the unlocked door a little bit more open in order to enter the goal chamber and obtain reward. On both days each animal was given three trials. On each trial the rat was allowed to drink for 10 seconds before being removed from the goal box and returned to its home cage. The animals were run in squads of 6 animals in order to maintain an inter trial interval of 2 - 5 minutes.

Days 8 - 10. The number of trials was increased from 5 to 9, and then to 12 trials per day. The gray doors were closed but unlocked on both sides. A record was made of the position preference of each animal.

Days 11 - 13. In order to break any position preference of each animal one of the gray doors was locked on each trial. The position of the unlocked door was randomly varied according to Fellow's sequence (1967). On each day 6 experimenter corrected spaced trials were given in the following way. If the animal touched the locked door it was picked up and given another run. Extra runs were given until the animal ran to the correct side, without first touching the locked door. Approaches to the locked door without touching it were permitted. Thus, the animal could make more than one run, but could only receive one reinforced run per trial. An error could easily be observed since the locked door

would budge 5.0 mm. if touched.

Upon completion of this phase the animals were assigned randomly to one of the two water deprivation levels. One group (MOD) was placed under a moderate deprivation schedule and received 6 hours of access to water per 24 hours. The other group (HI) received only 0.5 hours access to water per 24 hours. Water was always given in the rat's home cage immediately following the end of each experimental session. Both groups received food ad lib. In order to establish adjustment to the assigned deprivation levels the animals were not run on the following 3 days. Drinking water was supplied on approximately the same time as on the training days.

Throughout the experiment the animals were run at approximately the same time every day. During training and testing two squads of 6 animals were run one after another for 12 spaced trials a day, such that inter trial interval ranged from 2 to 5 minutes. The procedure for all trials consisted of placement of the rat into the start-box. As soon as the animal faced the plexiglass door, the door was raised allowing the rat to enter the decision chamber. The guillotine door was closed in order to prevent the animal from returning to the start-box. Entry into a goal chamber was only allowed on a correct run as indicated by the relevant cue(s). The rat remained in the goal chamber for a 10 sec. drink of the available solution. After reinforcement the animal was removed to its home cage. The following trial was given after all animals in the squad had completed their

trial.

To control for odour trials the floor of the apparatus was kept clean at all times and the floor was wiped with a damped cloth after each training session. The spouts of the drinking bottles were kept free of sugar at all times and possible drops of solution in the goal box were removed in between runs.

Discrimination training. Within each drive group, animals were randomly assigned to one of three simultaneous discrimination tasks: Redundant Relevant Cues (RRC), Relevant Brightness - Irrelevant Texture Cues (RBC), and Relevant Texture - Irrelevant Brightness Cues (RTC). Thus, there existed six independent drive discrimination groups each containing 8 animals. Throughout this report the groups will be indicated by their respective deprivation level and their discrimination task in this manner: HI -RRC, HI-RBC, HI-RTC, MOD-RRC, MOD-RBC, MOD-RTC.

The brightness dimension consisted of attributes of a gray and black door, while the attributes on the texture dimension were the smooth and rough halfs of the decision chamber floor. When either or both dimensions were relevant the black door and/or the rough floor side were the positive stimuli. For the RRC task the position of the black door and rough half of the floor (S+'s) always occurred on the same side on any one trial. For the RBC and RTC taks, the position of each attribute was randomly varied independently, for 50% correlation, i.e. on half the trials the rough and

black cues appeared on the same position and on the other trials on the opposite side. Position of the individual attributes on each trial was determine by the Fellow's (1967) random sequence.

Reinforcement was gained by RRC animals by running down the rough side of the floor and pushing open the black door. In the RBC task, pushing open the black door irrespective of floor texture leading to it secured reinforcement for the animal. In the RTC task, running down the rough side of the floor and pushing open the door on that side, irrespective of its shade, led to reinforcement for the animal. The door associated with the negative brightness and/or texture cue was always locked. If the rat touched the locked door the experimenter corrected procedure as described for days 11 - 13 was used. An animal could thus make more than one error on a single trial. All errors and running time on the correct run were recorded for each trial.

Two different incentives of 0% (tap water) and 20% sucrose solution (wt/v) were systematically presented to each animal during the discrimination training. Each incentive was correlated with a specific goal chamber. Position of each incentive was determined by the previously preferred goal chamber established during the shaping phase. A counterbalanced position procedure was followed so that the 20% incentive was constantly maintained on the preferred side and the 0% incentive on the nonpreferred side for half the animals in each group. The opposite sides were used for the

remaining animals in each group. Therefore, type of incentive on each trial was determined by the position of the positive stimulus or stimuli (for the RRC animals). Random positioning of S+ not only prevented alternation from becoming a relevant dimension, but also presented each incentive in a random sequence. This procedure prevented animals from learning an incentive pattern during discrimination trials. Thus, within any one experimental session (12 trials) an animal received half its trials with one incentive and half with the other. In this manner all animals received successive incentive presentation within the simultaneous discrimination tasks.

All animals were run to a discrimination learning criterion of two or fewer errors within 24 consecutive trials (two trial blocks). Any difference in speed could be attributed to incentive preference rather than discrimination learning. However, to allow for a more stable association between incentive and position, the animals were given 3 days of overtraining. The overtraining sessions helped to establish the reliability of running speed to each incentive. Within any trial running time was only recorded for a correct run.

Testing. The testing phase was designed to test the position preference of the animals in a free choice situation. On the test trials both incentive positions were presented simultaneously. The animal was given 3 test days of the 12 trials per day. Each third trial was a test trial. The inter test trials were the same as during the animal's.

respective discrimination training. The procedure of mixing test trials with discrimination trials was intended to minimize the possible disruptive effect of occurrence of a position habit. It was also used to prevent test trials from becoming specific discrimination learning trials for the subject. On each test trial the animal was presented with the relevant positive cue(s) on both sides. Thus, the RRC group was presented with a rough texture on the left and on the right side of the decision chamber and black doors in front of both goal chambers. The RTC group received the rough texture on both sides and the RBC group was presented with two black doors. For the RTC and RBC groups the irrelevant cues were presented in random position as during discrimination learning trials.

During the test trials both doors were unlocked and reinforcement could be obtained in either goal box. The position of the 0% and the 20% sucrose solutions remained constant for each individual animal on test and discrimination trials. The animal was reinforced for its first choice, i.e. the first door it pushed open. The choice of position provided the data for the preference of incentive position on a total of 12 test trials. Running time was recorded for the inter test trials. In order not to influence the incentive position choice on the test trials the following precautions were taken. Preceding each test trial there occurred two regular discrimination trials. During each test day an animal received S+ twice on the right, twice on the left,

left then right, and right then left in front of a test trial. The presentation of these pairs of trials were randomly distributed. Thus, equal numbers of test trials were preceded by two 20% incentive reinforcements, two 0% incentive reinforcements, and an alternating set of incentives. Position choice during the test trials could not be considered to be due to the introduction of novel stimuli since all animals had been presented with both texture and brightness cues.

CHAPTER III

Results

Original discrimination training

Acquisition differences between the various drive-task groups were measured by trial blocks (Table 1a, p. 34) and errors (Figure 2, p. 33) to criterion. Table 1a (p. 34) represents the mean number of trial blocks required to learn the discrimination task by HI and MOD drive animals in the three discrimination tasks. Animals which were trained in the discrimination task with two relevant cues (RRC task) required less trial blocks to reach the learning criterion than the animals trained with one relevant and one irrelevant dimension (RBC and RTC). HI animals in the RBC group (brightness relevant) also learned their discrimination faster than animals in the RTC (texture relevant) group. However, MOD-RBC animals required some what more trial blocks to criterion than the other groups. HI animals trained in the RRC or RBC task required less training days than the MOD animals in the same respective discrimination task group. The difference between drive groups in the RBC task was greater than in the RRC task. No difference in number of trial blocks to criterion was observed between drive groups in the RTC task. A drive x discrimination task factorial analysis (see Table 1b, p. 35) revealed significant main effects of drive- ($F = 7.43$, $df = 1/42$, $p < .01$), and of discrimination task

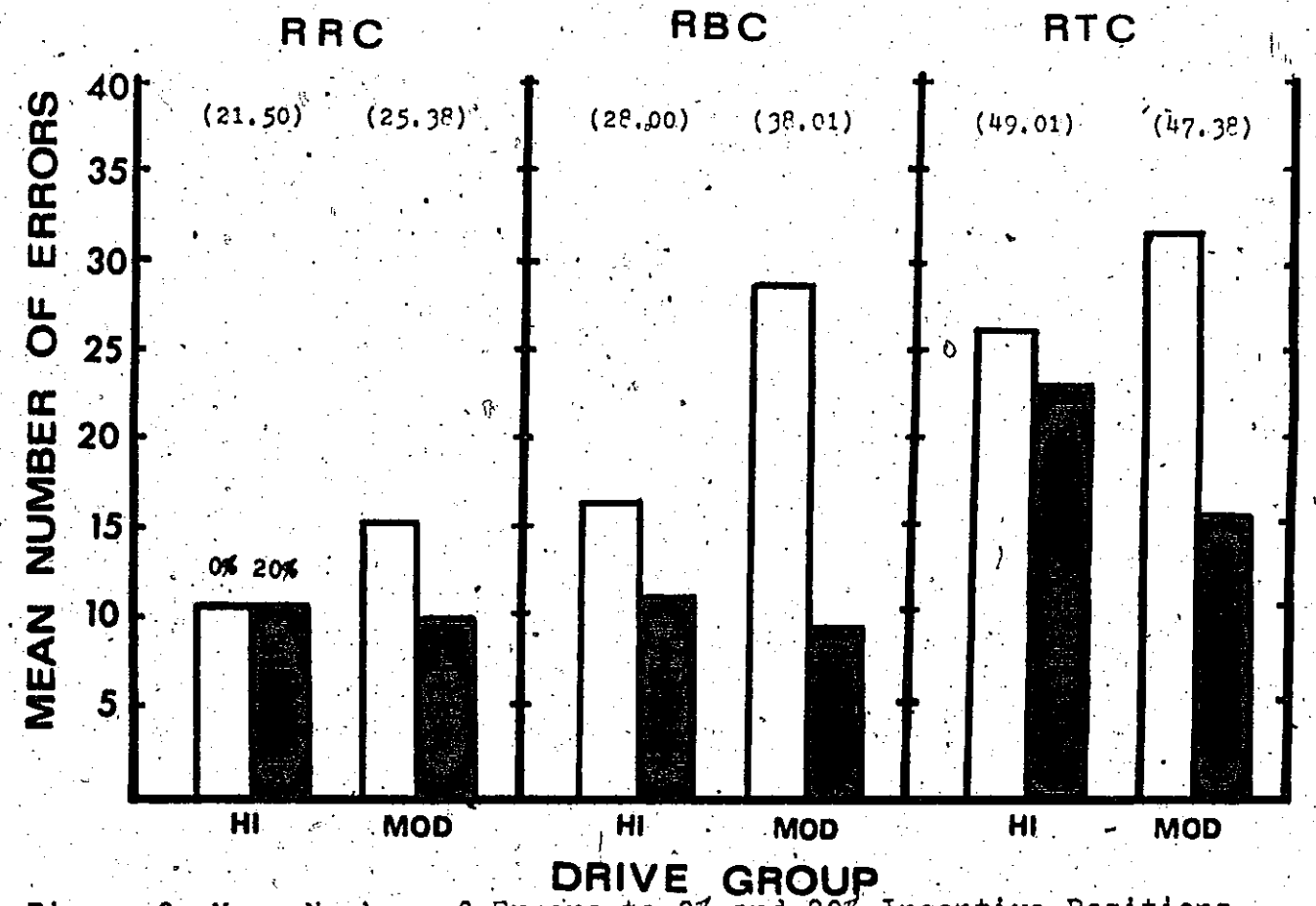

Figure 2. Mean Number of Errors to 0% and 20% Incentive Positions for HI and MOD Drive Groups within each Discrimination Task. Mean Number of Errors to Criterion over both Positions in Parentheses.

TABLE 1a

Mean Number of Trial Blocks (12 Trials per Block) to Criterion (Standard Deviations in Parentheses)

	HI Drive	
RRC	5.13	(0.92)
RBC	6.50	(1.65)
RTC	8.13	(2.96)
	MOD Drive	
RRC	6.25	(1.61)
RBC	9.00	(1.63)
RTC	8.38	(1.13)

TABLE 1b.

ANOVA on Trial Blocks to Criterion for

Drive x Discrimination Task

Source of Variation	SS	df	MS	F
A(drive)	20.02	1	20.02	7.43**
B(discrimination task)	59.04	2	29.52	10.96**
AB	10.29	2	5.15	1.91
Within cell	113.13	42	2.69	

** $p \leqslant .01$

($F = 10.96$, $df = 2/42$, $p < .01$). The interaction effect did not reach significance. Individual comparisons were carried out in this and all other parametric statistics by the Newman-Keuls procedure. The individual comparisons between discrimination task treatment with drive collapsed (Table 1c, p. 37) found that under the RRC task animals learned the discrimination significantly faster ($p < .01$) than under the other two tasks. No significant differences were found between the REC and RTC groups. Comparisons between discrimination tasks within each drive condition revealed that HI-RRC animals required significantly less training days than the HI-RTC animals ($p < .01$), but neither group differed significantly from the HI-REC animals. In the moderate drive level condition RRC animals learned the task in significantly fewer trial blocks than the REC ($p < .01$) and the RTC animals ($p < .05$). Individual comparisons between drive groups trained under the same discrimination task (Table 1c, p. 37) indicated that only HI animals in the REC condition required significantly fewer days to criterion than the MOD-REC animals ($p < .01$). No significant difference in training days to criterion was found between HI and MOD animals in the RRC and RTC condition. Rate of learning thus was faster for RRC animals under both drive level conditions. REC animals learned at a rate similar to RRC animals under high drive condition, MOD-RRC animals learned their task sooner than either MOD-REC or MOD-RTC group. Only within the REC task were drive differences found. HI animals acquiring the discrimination

TABLE 1c

Individual Comparisons (Newman-Keuls procedure) of RRC, RBC, and RTC groups for HI and MOD Drive Level on Number of Trials to Discrimination learning Criterion

HI drive vs MOD drive			q
RRC			1.94
RBC	HI	MOD	4.32**
RTC			0.43

RRC vs RBC vs RTC (drive collapsed)		q
RRC	RBC	10.06**
RRC	RTC	12.50**
RBC	RTC	2.44

RRC vs RBC vs RTC (Within drive)		q
HI Drive		
RRC	RBC	2.37
RRC	RTC	5.17**
RBC	RTC	2.80
MOD Drive		
RRC	RBC	4.74**
RRC	RTC	3.66**
RBC	RTC	1.08

** p .01

more quickly than MOD animals.

Errors to criterion were measured in two ways. First, total errors to criterion were recorded in order to determine the differences between the tasks within each drive and the difference between drive levels within each task. Secondly, errors made when S+ was at each incentive position were recorded. It will be recalled that S+ appeared equally on the 0% and 20% incentive sides for each animal. With this data it was possible to determine if animals under each drive within each task responded differentially in number of errors to incentive positions. Mean number of errors over both positions and for each incentive position for each drive-task group are shown in Figure 2 (p. 33). It appeared that the RRC task was learned with fewer errors than the RBC or RTC tasks by animals within each drive condition. For both drive groups the RTC task appeared to be the most difficult task to master. Only within the RBC task were clear drive differences found. HI animals learned the RBC task with fewer errors than MOD animals. Only a slight difference in this direction was observed between drive groups in the RRC and RTC tasks.

For errors to each position, MOD animals in all tasks were observed to commit more errors when S+ was positioned on the 0% than when it was positioned on the 20% side. No such difference existed for HI-RRC animals but in the two other tasks HI rats also committed more errors to the S+ on the 0% than on the 20% position. Within each task, however,

HI animals made fewer errors to the 0% than MOD animals. To the 20% side an opposite but smaller difference appeared, i.e., HI animals made more errors to the S+ on the 20% side than MOD animals. The latter difference was barely noticeable in the RRC task and appeared to be greatest in the RTC task.

A drive x discrimination task x incentive position (repeated factor) ANOVA was carried out on the error data (see Table 2a, p. 40). Significant main effects for discrimination task ($F = 12.02$, $df = 2/42$, $p < .01$), and incentive ($F = 32.69$, $df = 1/42$, $p < .01$) were found. The interaction effects between discrimination task and incentive ($F = 4.00$, df 2/42, $p < .05$), and between incentive and drive ($F = 13.66$, $df = 1/42$, $p < .01$) were also significant. Main effect for drive, however, was not significant. In order to determine the differential effect of discrimination task treatments individual comparisons were carried out between the three treatments for each drive separately (see Table 2b, p. 41). The comparison with incentive collapsed revealed, that within each drive group animals made significantly more errors in learning the RTC than the RRC or the RBC task ($p < .01$). Only for MOD animals, however, were significantly more errors committed in learning the RBC than the RRC task ($p < .01$). Furthermore, drive differences were only found significant in the RBC task, in that MOD-RBC animals made more errors than HI-RBC animals ($p < .01$). The small differences in errors between drive groups in the RRC

TABLE 2a

ANOVA on Number of Errors to Criterion for Drive x Discrimination task x Incentive

Source of Variation	SS	df	MS	F
Between Subjects	7083.63	47		
A (discrimination task)	2492.44	2	1246.22	12.01**
C (drive)	100.04	1	100.04	0.97
AC	135.27	2	67.64	0.65
Subjects within groups	4355.88	42	103.71	
Within subjects	4900.00	48		
B (incentive)	1633.50	1	1633.50	32.69**
AB	400.19	2	200.06	4.00*
BC	682.67	1	682.67	13.66**
ABC	84.77	2	42.39	0.85
B x subjects within groups	2098.88	42	49.97	

** $p \leqslant .01$

* $p \leqslant .05$

TABLE 2b

Individual Comparisons (Newman-Keuls procedure) of Drive x Discrimination Task Groups on Total Number of Errors during Discrimination Training

RRC vs RBC vs RTC (incentive collapsed)			q
HI Drive			
RRC	RBC		2.55
RRC	RTC		10.78**
RBC	RTC		8.24**
MOD Drive			
RRC	RBC		4.95**
RRC	RTC		8.63**
RBC	RTC		3.68**

HI vs MOD (incentive collapsed)			q
RRC			1.52
RBC	HI	MOD	3.95**
RTC			0.64

** p < .01

and RTC tasks were not significant. Individual comparisons within each discrimination task group for number of errors to each incentive position separately are shown in Table 2c (p. 43). Only the MOD-RBC and MOD-RTC animals made significantly less errors to the 20% than to the 0% position ($p < .01$). None of the differences observed in the HI-RBC, HI-RTC, or MOD-RRC were significant. HI-RRC animals as observed failed to show any significant error differences between incentives. Individual comparisons within each discrimination task between drive levels at each incentive indicated that only MOD-RBC animals made significantly more errors to the 0% position than HI-RBC animals ($p < .01$). No other differences between drives at either incentive position within each task were found to be significant.

In summary, RRC animals acquired their respective discrimination faster than the other groups. Drive level effected rate of learning less in the RRC and RTC groups than in the RBC group, in which the MOD animals made more errors to the 0% position than the HI animals. Incentive position affected learning in MOD-RTC and MOD-RBC animals, such that both groups made more errors to the 0% position than to the 20% position. No such difference was found in the MOD-RRC group.

Running speed during the discrimination training. During the two criterion and three overtraining days running time on each trial was measured to the nearest 0.1 sec., and then transformed into a reciprocal speed measure.

TABLE 2c

Individual Comparisons (Newman-Keuls procedure) of Drive Groups on Number of Errors to 0% and 20% Incentive Positions during Discrimination Training

HI vs MOD			q
0% position			
RRC			1.49
RBC	HI	MOD	3.83**
RTC			1.81
20% position			
RRC			0.24
RBC			0.61
RTC			2.34

0% vs 20% position			q
HI Drive			
RRC			0.00
RBC			2.20
RTC			1.30
MOD Drive			
RRC			2.15
RBC	0%	20%	7.70**
RTC	0%	20%	6.45**

** p .01

Reciprocal scores were used to normalize typically skewed running time scores and thus permitted parametric statistical analysis (Winer, 1971). Two measures of running speeds were employed in the discrimination phase. The first measure was the mean daily running speed for each drive x discrimination task group to each incentive position (see Figure 3, p. 45). This mean speed was calculated from the mean running speed on the respective 6 trials to each incentive position for each animal in each trial block. This measure tapped two possible sources of speed differences, speed based on learned incentive-position associations and speed based on incentive experience from the immediately preceding trial. A second method of measuring speed to each incentive was used to eliminate to some degree the second possibility. Speed scores to only those trials which had been following a trial in which the opposite incentive position had been reinforced was calculated. The very first trial was also used. By this criterion ~~there were 3 low~~ incentive and 3 high incentive trials which had followed the opposite incentive within each trial block. Mean running speeds for each position were therefore calculated only from the first reinforced position on that trial block and the first position following a trial in which the opposite position had been reinforced. The drive x discrimination task group means on such first position trials for each incentive are presented in Figure 4 (p. 46).

The animals made some errors during the two criterion days (a maximum of two) and during the overtraining days.

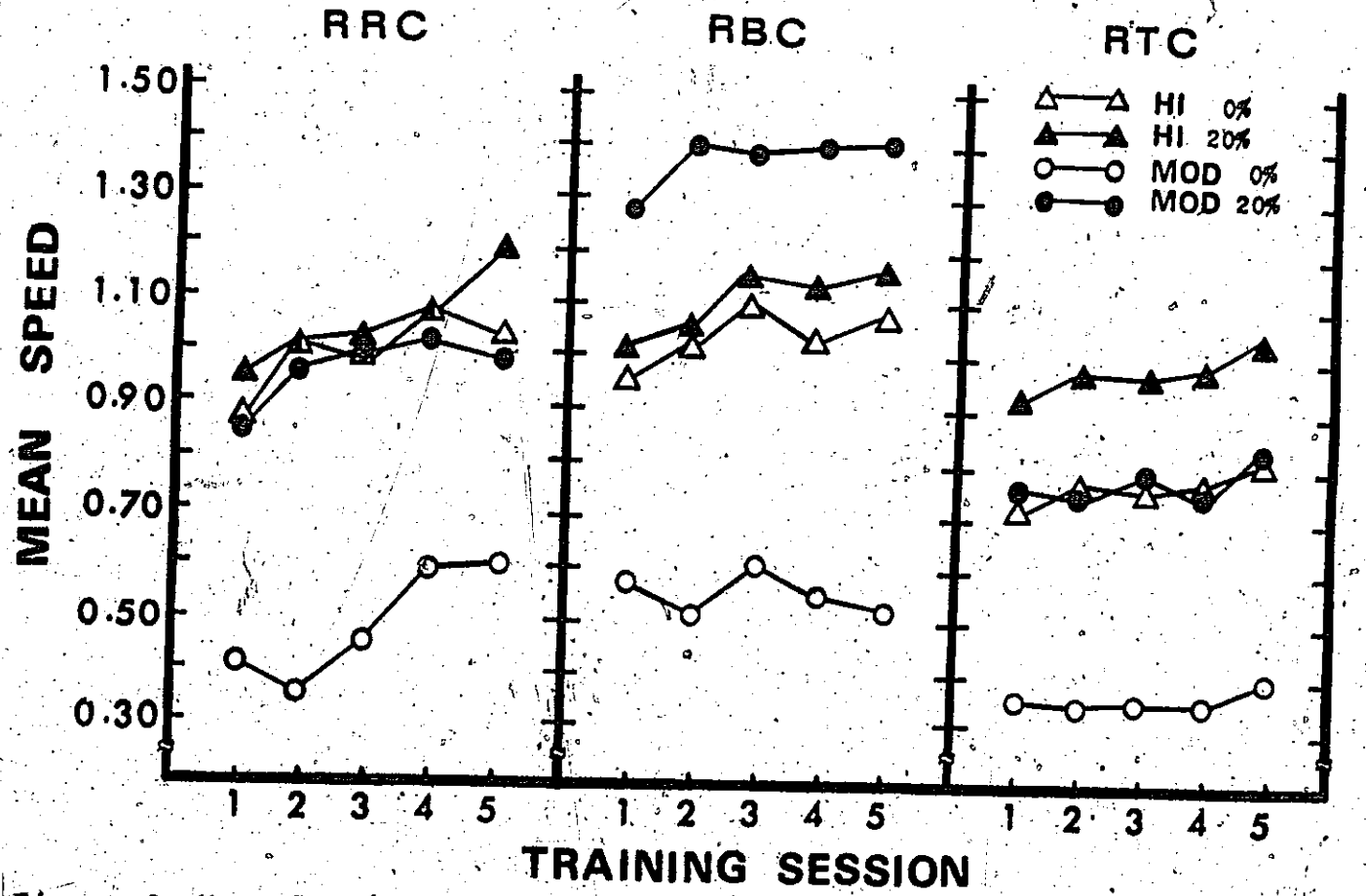

Figure 3. Mean Running Speed over all Daily Trials to 0% and 20% Incentive Positions for HI and MOD Drive Groups within each Discrimination Task during two Criterion and three Overtraining Sessions.

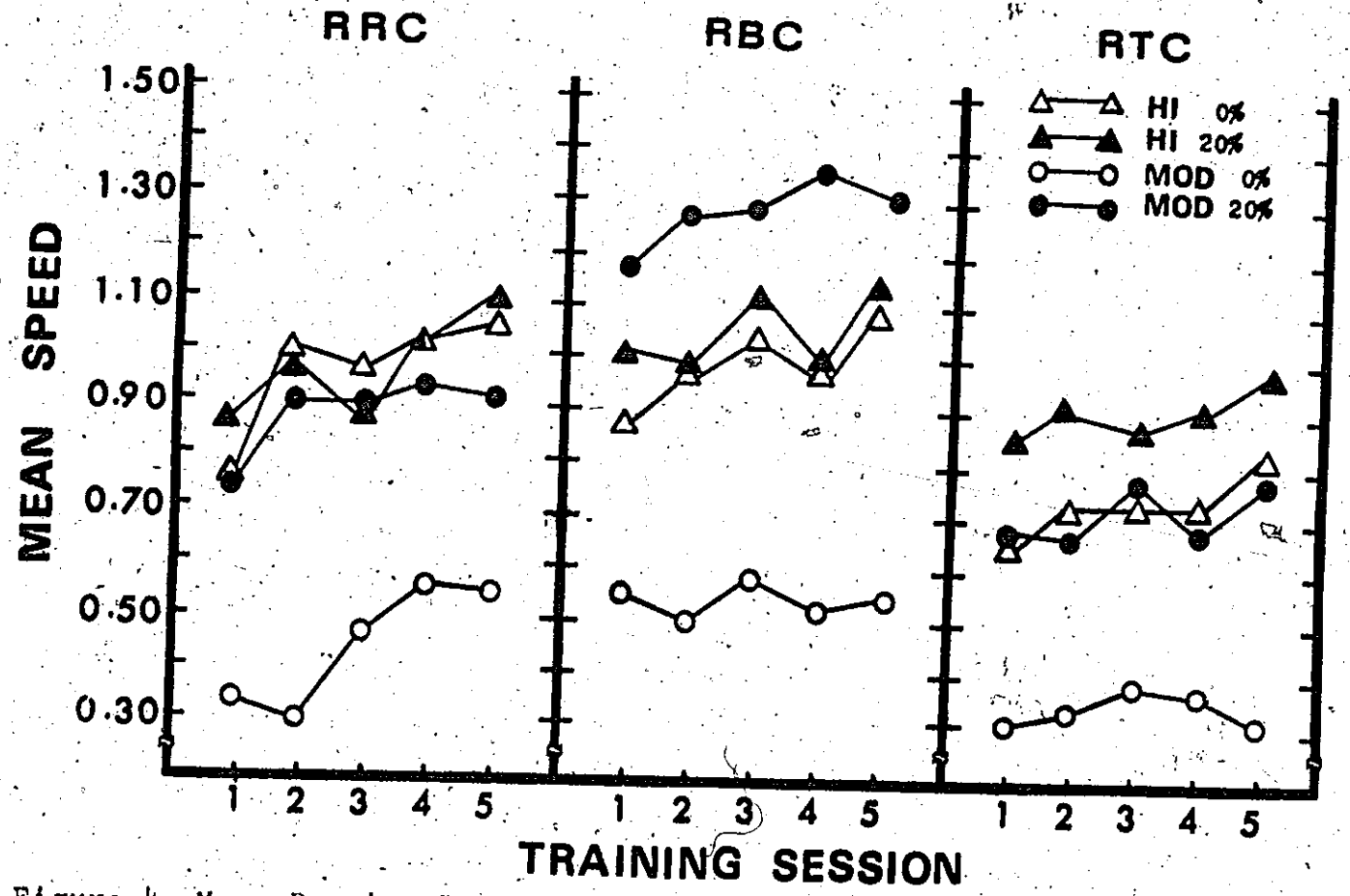

Figure 4. Mean Running Speed over First Trials only to 0% and 20% Incentive Positions for HI and MOD Drive Groups within each Discrimination Task during two Criterion and three Overtraining Sessions.

Three MOD animals made as many as five errors to the 0% position. In order not to influence speed scores by errors, the experimenter corrected procedure was employed throughout the successive presentation sessions. Only the running speed of the correct run within that trial was used.

Mean running speed to each position for all trials (Figure 3, p. 45) or only for first trials (Figure 4, p. 46) indicated that MOD animals in each of the discrimination tasks displayed differential running speeds to the incentive positions. For both speed measures MOD animals showed a faster running speed when the S+ denoted the 20% incentive position, than when reinforcement could be obtained at the 0% position. In the HI drive groups only the RTC animals appeared to show a response differentiation which was similar to that of the MOD animals. The HI-RBC animals ran only slightly faster to the 20% position while the HI-RRC animals showed no difference until the fifth trial block. Within the RRC task MOD drive animals appeared to show a similar running speed to the 20% position as HI drive animals to either of the positions. MOD-RBC animals, however, ran faster than the HI animals to the 20% position. The latter difference was found to be reversed in the RTC task in which the HI animals ran faster to the 20% position. Running speed of MOD-RTC animals to the 20% position appeared to be similar to the response displayed to the 0% position by the HI-RTC animals.

For each speed measure a discrimination task x drive x incentive (repeated measure) x trial blocks (repeated measure)

ANOVA was carried out. The findings of the ANOVA on mean daily running speed are presented in Table 3a (p. 49). For the mean speed over all trials significant main effects were found for discrimination task ($F = 7.92$, $df = 2/42$, $p < .01$), for drive ($F = 14.45$, $df = 1/42$, $p < .01$), for incentive ($F = 79.91$, $df = 1/42$, $p < .01$), and for trial blocks ($F = 7.05$, $df = 4/168$, $p < .01$). Individual comparisons (see Table 3b, p. 50) indicated that the animals in the RBC task ran significantly faster than the animals in the RRC and RTC tasks respectively ($p < .01$). The RTC animals showed the slowest running speed and differed significantly with the RRC animals ($p < .01$). Individual comparisons between trial blocks indicated that running speed was significantly slower on day 1 than on day 3 and 4 ($p < .05$) and day 5 ($p < .01$). Running speed on day 2 was furthermore significantly slower than on day 5 ($p < .05$). Differences in running speed between the other trial blocks did not reach significance. Significant interactions were obtained for drive x incentive ($F = 35.94$, $df = 1/42$, $p < .01$), for discrimination task x drive x incentive ($F = 3.89$, $df = 2/42$, $p < .05$), and for trial blocks x incentive x drive ($F = 2.69$, $df = 4/168$, $p < .05$). Individual comparisons were carried out for each trial block separately to determine the effect of incentive (see Table 3b, p. 50) and/or drive (Table 3c, p. 51) within each discrimination task condition. HOD animals in each of the discrimination task groups showed a significantly slower running speed to the 0% position than to the 20% position on

TABLE 3a

A Drive x Discrimination Task x Incentive (repeated factor) x Sessions (repeated factor) ANOVA for Mean Running Speed over all Trials

Source of Variation	SS	df	MS	F
Between Subjects	33.69	47		
A (discrimination task)	7.05	2	3.52	7.92**
D (drive)	6.87	1	6.87	15.45**
AD	1.09	2	0.54	1.22
Subjects within groups	18.69	42	0.45	
Within Subjects	38.08	432		
B (trial blocks)	0.69	4	0.17	7.05**
AB	0.31	8	0.04	1.59
BD	0.04	4	0.01	0.45
ABD	0.07	8	0.01	0.35
B x subjects within groups	4.09	168	0.02	
C (incentive)	14.17	1	14.17	79.91**
AC	0.83	2	0.42	2.35
CD	6.37	1	6.37	35.94**
ACD	1.38	2	0.69	3.89*
C x subjects within groups	7.45	42	0.18	
BC	0.02	4	0.01	0.45
ABC	0.04	8	0.01	0.34
BCD	0.15	4	0.04	2.69*
ABCD	0.19	8	0.02	1.74
BC x subjects within groups	2.29	168	0.01	

** $p \leq .01$

* $p \leq .05$

TABLE 3b

Individual Comparisons (Newman-Keuls procedure) on Daily Mean Running Speed to Incentive Positions within each Drive x Discrimination Task Group for each Trial Block seperately

	HI Drive 0% vs 20%				MOD Drive 0% vs 20%	
Day	Task		q	Day	Task	q
1	RRC		1.09	1	RRC	0 < 20 6.12**
	RBC		1.79		RBC	0 < 20 9.36**
	RTC		2.76		RTC	0 < 20 5.47**
2	RRC		0.92	2	RRC	0 < 20 8.03**
	RBC		0.72		RBC	0 < 20 11.80**
	RTC	0 < 20	2.91*		RTC	0 < 20 5.60**
3	RRC		0.51	3	RRC	0 < 20 7.03**
	RBC		0.91		RBC	0 < 20 10.37**
	RTC	0 < 20	2.77*		RTC	0 < 20 5.81**
4	RRC		0.27	4	RRC	0 < 20 5.63**
	RBC		1.41		RBC	0 < 20 11.57**
	RTC		2.48		RTC	0 < 20 5.59**
5	RRC		2.37	5	RRC	0 < 20 5.25**
	RBC		0.12		RBC	0 < 20 11.68**
	RTC	0 < 20	3.35*		RTC	0 < 20 5.53**

** $p \leq .01$

* $p \leq .05$

TABLE 3c

Individual Comparisons (Newman-Keuls procedure) for Differences between Drive Levels at each Incentive for each Discrimination Task for each Trial Block seperately for Running Speed for Daily Means During Discrimination Training

	0% Position				20% Position		
	HI vs MOD				HI vs MOD		
Day	Task		q	Day	Task		q
1	RRC	H > M	4.67**	1	RRC		0.90
	RBC	H > M	3.73**		RBC		1.95
	RTC	H > M	3.54*		RTC		1.75
2	RRC	H > M	7.09**		RRC		0.38
	RBC	H > M	4.84**		RBC	H < M	3.47*
	RTC	H > M	4.29**		RTC		2.27
3	RRC	H > M	5.61**	3	RRC		0.04
	RBC	H > M	4.72**		RBC		2.38
	RTC	H > M	4.07**		RTC		1.79
4	RRC	H > M	4.77**	4	RRC		0.75
	RBC	H > M	4.73**		RBC	H < M	2.89*
	RTC	H > M	4.38**		RTC		2.05
5	RRC	H > M	4.26**	5	RRC		2.10
	RBC	H > M	5.50**		RBC		2.33
	RTC	H > M	4.04**		RTC		2.40

** $p \leq .01$

* $p \leq .05$

each of the 5 trial blocks ($p < .01$). HI-RTC animals showed a somewhat similar response pattern, in that running speed was significantly faster to the 20% position on 3 of the 5 trial blocks (day 2, 3, and 4, $p < .05$). Neither HI-RRC nor HI-RBC groups displayed faster running speeds to the 20% position on any one of the trial blocks. Thus, only MOD animals in each of the 3 discrimination tasks and HI-RTC animals showed differential running speed to the two incentive positions. The individual comparisons for differences between drive groups within each discrimination task for each incentive position separately are presented in Table 3c (p. 51). HI animals in all three discrimination tasks ran significantly faster to the 0% position than the MOD animals within the same respective discrimination task ($p < .01$ in all cases, except for the difference in RTC task on day 1, $p < .05$). For the 20% position no significant differences were found HI and MOD animals in the RRC and RTC conditions. MOD-RBC animals, however, ran significantly faster to the 20% position than HI-RBC animals on day 2, and 4 ($p < .05$). Differences between drive groups thus were found in all three discrimination tasks for the 0% position, but only RBC animals showed a drive level difference in running speed to the 20% position.

A discrimination task x drive x incentive (repeated measure) x trial blocks (repeated measure) ANOVA on mean speed on first trials only was carried out (see Table 4a, p. 53). The same significant main effects were revealed as

TABLE 4a

A Drive x Discrimination Task x Incentive (repeated factor) x Sessions (repeated factor) ANOVA for Mean Running Speed over First Trials

Source of Variation	SS	df	MS	F
Between Subjects	31.88	47		
A (discrimination task)	6.66	2	3.33	7.91**
D (drive)	6.63	1	6.63	15.75**
AD	0.92	2	0.46	1.10
Subjects within groups	17.67	42	0.42	
Within Subjects	37.01	432		
B (trial blocks)	1.23	4	0.31	8.70**
AB	0.33	8	0.04	1.16
BD	0.17	4	0.04	1.21
ABD	0.18	8	0.02	0.63
B x subjects within groups	5.92	168	0.03	
C (incentive)	10.85	1	10.85	63.85**
AC	0.59	2	0.29	1.73
CD	5.45	1	5.45	32.10**
ACD	1.23	2	0.62	3.62*
C x subjects within groups	7.14	42	0.17	
BC	0.02	4	0.01	0.28
ABC	0.09	8	0.01	0.58
BCD	0.13	4	0.03	1.65
ABCD	0.39	8	0.05	2.50*
BC x subjects within groups	3.29	168	0.02	

** $p \leq .01$

* $p \leq .05$

in the ANOVA on daily mean speed: for discrimination task ($F = 7.91$, $df = 2/42$, $p < .01$) for drive ($F = 15.75$, $df = 1/42$, $p < .01$), for incentive ($F = 63.85$, $df = 1/42$, $p < .01$), and for trial blocks ($F = 8.70$, $df = 1/168$, $p < .01$). Individual comparisons between discrimination tasks (Newman-Keuls procedure) indicated that the RBC animals ran significantly faster than the RRC and RTC animals respectively ($p < .01$). RRC animals also showed a significant faster running speed than RTC animals ($p < .05$). Differences in running speed between trial blocks only revealed significance when comparing day 1 with day 3, 4 and 5 ($p < .01$). The ANOVA for mean speed on first trials similarly indicated significant interaction effects for drive x incentive ($F = 32.10$, $df = 1/42$, $p < .01$), and for discrimination task x drive x incentive ($F = 3.62$, $df = 2/42$, $p < .05$). No significant interaction was found between trial blocks x drive x incentive as in the ANOVA on mean daily speed. However, the interaction effect between all four factors was found to be significant ($F = 2.50$, $df = 8/168$, $p < .05$). Individual comparisons for the data of first trials only (Table 4b, p. 55, and Table 4c, p. 56), revealed great similarity with the mean daily speed data, although the differences between groups did not always reach the .05 level of significance. MOD drive animals in all three discrimination task groups ran significantly faster to the 20% than to the 0% position for each of the trial blocks ($p < .01$). The difference in running speed to 20% and 0% position for HI-RTC animals barely missed significance in the measure on

TABLE 4b

Individual Comparisons (Newman-Keuls procedure) on Mean Running Speed on First Trials only to Incentive Positions within each Drive x Discrimination Task Group for each Trial Block

	HI Drive 0% vs 20%			MOD Drive 0% vs 20%		
Day	Task	q	Day	Task		q
1	RRC	1.33	1	RRC	0 < 20	4.99**
	RBC	1.95		RBC	0 < 20	7.84**
	RTC	2.63		RTC	0 < 20	4.95**
2	RRC	0.98	2	RRC	0 < 20	7.66**
	RBC	0.42		RBC	0 < 20	9.73**
	RTC	2.66		RTC	0 < 20	4.22**
3	RRC	1.09	3	RRC	0 < 20	5.53**
	RBC	1.08		RBC	0 < 20	8.96**
	RTC	1.90		RTC	0 < 20	4.77**
4	RRC	0.11	4	RRC	0 < 20	4.71**
	RBC	0.70		RBC	0 < 20	10.41**
	RTC	2.48		RTC	0 < 20	4.01**
5	RRC	2.34	5	RRC	0 < 20	4.48**
	RBC	0.75		RBC	0 < 20	9.70**
	RTC	2.06		RTC	0 < 20	5.66**

** $p \leq .01$

TABLE 4c

Individual Comparisons (Newman-Keuls procedure) for Differences between Drive Levels at each Incentive for each Discrimination Task for each Trial Block seperately on Running Speed on First Trials

	0% Position				20% Position		
	HI vs MOD				HI vs MOD		
Day	Task		q	Day	Task		q
1	RRC	H > M	4.14**	1	RRC		1.25
	RBC	H > M	3.06*		RBC		1.59
	RTC	H > M	3.46*		RTC		1.63
2	RRC	H > M	7.39**	2	RRC		0.57
	RBC	H > M	4.45**		RBC	H < M	2.91*
	RTC	H > M	3.96**		RTC		2.73
3	RRC	H > M	14.42**	3	RRC		0.25
	RBC	H > M	4.55**		RBC		1.68
	RTC	H > M	3.34*		RTC		1.07
4	RRC	H > M	4.68**	4	RRC		0.87
	RBC	H > M	4.42**		RBC	H < M	3.25*
	RTC	H > M	3.72**		RTC		2.51
5	RRC	H > M	3.88**	5	RRC		2.19
	RBC	H > M	6.15**		RBC		2.10
	RTC	H > M	5.07**		RTC		2.23

** $p \leq .01$

* $p \leq .05$

first trials, however. HI-RBC and HI-RRC animals showed no significant difference either, as for the mean daily speed measures. Differences between drive groups for each position separately indicated again that all HI animals ran significantly faster to the 0% position than the MOD animals ($p < .05$, for RBC and RTC on day 1, and for RTC on day 3, $p < .01$ in all other comparisons). On days 2 and 4 MOD-RBC animals showed a significantly faster running speed on the first trials to the 20% position than HI-RBC animals ($p < .05$). No significant drive difference were found in the RTC and RRC groups for the 20% position on any of the criterion or overtraining days.

In summary, the running speed data for mean daily speed, and for first trials only indicated that all MOD animals showed response speed differentiation between positions. These animals ran faster to the 20% than to the 0% position. In the HI drive groups only RTC animals showed similar response differentiation for the mean daily running speed measure. For the measure of first trials only, none of the HI drive groups displayed significant response differentiation. HI drive animals did run faster to the 0% position than MOD drive animals in the same discrimination task condition. Differences between drive groups to the 20% position were only found in the RBC task in which MOD animals ran faster than HI animals.

Test phase

Running Speed. Mean running speed to each position

during the 8 inter test discrimination trials on each block was also calculated (see Figure 5, p. 59). As during the discrimination training NOD animals in each of the three discrimination task groups appeared to show a large difference between running speed to the 0% and to the 20% position. The HI animals in the RTC group showed greater differential responding in the same direction than the HI animals in the RRC and RBC groups, who also showed a slight difference. The ANOVA on discrimination task x drive x incentive (repeated measure) x test blocks (repeated measure) is presented in Table 5a (p. 60). Significant main effects were found for discrimination task ($F = 3.44$, $df = 2/42$, $p < .01$), for drive ($F = 25.37$, $df = 1/42$, $p < .01$), for incentive ($F = 178.15$, $df = 1/42$, $p < .01$), and for test blocks ($F = 3.21$, $df = 1/84$, $p < .05$). Individual comparisons (Newman-Keuls procedure) on running speed between discrimination task groups revealed that RBC and RRC did not differ in running speed, but both groups ran significantly faster than the RTC group ($p < .01$). Individual comparisons between trial blocks did not reach significance. Interaction effects were found for incentive x discrimination task ($F = 5.63$, $df = 2/42$, $p < .01$), for incentive x drive ($F = 78.01$, $df = 1/42$, $p < .01$), and for incentive x drive x discrimination task ($F = 7.77$, $df = 2/42$, $p < .01$). Individual comparisons were carried out to determine the effects of drive and incentive within each discrimination group (Table 5b, p. 61, and Table 5c, p. 62). The comparison on running speed to the two positions within each

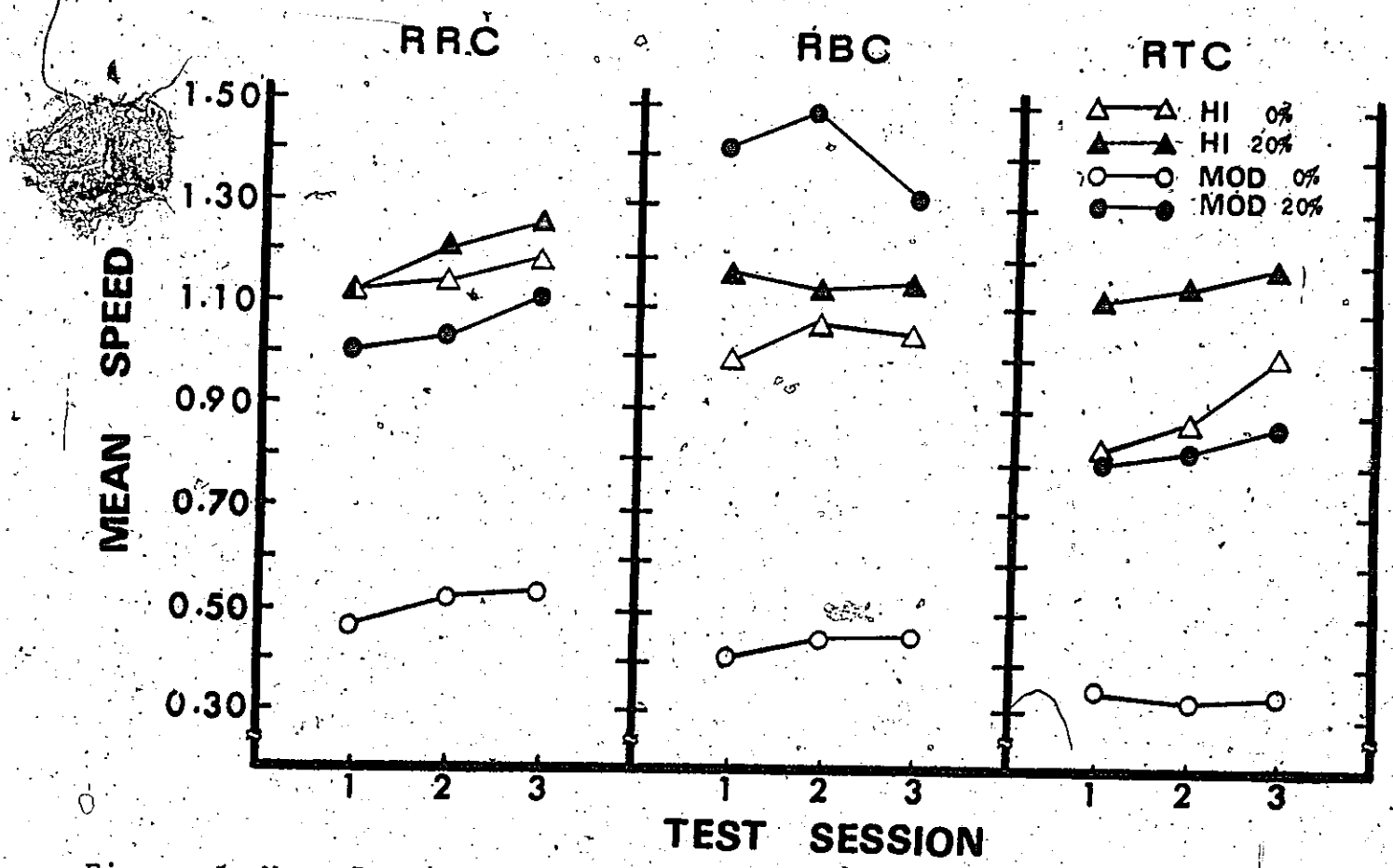

Figure 5. Mean Running Speed on the Inter Test Trials to 0 % and 20% Incentive Positions for HI and MOD Drive Groups within each Discrimination Task during three Test Sessions.

TABLE 5a

A Drive x Discrimination Task x Incentive (repeated factor) x Sessions (repeated factor) ANOVA for Mean Running Speed over Inter Test Trials

Source of Variation	SS	df	MS	F
Between Subjects	25.40	47		
A (discrimination task)	2.26	2	1.13	3.44*
D (drive)	8.34	1	8.34	25.37**
AD	0.98	2	0.49	1.48
Subjects within groups	13.82	42	0.33	
Within Subjects	25.02	240		
B (test blocks)	0.14	2	0.07	3.21*
AB	0.10	4	0.03	1.18
BD	0.04	2	0.02	0.85
ABD	0.02	4	0.01	0.22
B x subjects within groups	1.84	84	0.02	
C (incentive)	11.75	1	11.75	178.15**
AC	0.74	2	0.37	5.63**
CD	5.15	1	5.15	78.01**
ACD	1.03	2	0.51	7.77**
C x subjects within groups	2.77	42	0.07	
BC	0.02	2	0.01	0.54
ABC	0.04	4	0.01	0.71
BCD	0.00	2	0.00	0.12
ABCD	0.08	4	0.02	1.36
BC x subjects within groups	1.30	84	0.02	

** $p \leqslant .01$

* $p \leqslant .05$

TABLE 5b

Individual Comparisons (Newman-Keuls procedure) on Mean Running Speed on Inter Test Trials to Incentive Position within each Drive x Discrimination Task Group

HI Drive				MOD Drive			
Day	Task	0% vs 20%	q	Day	Task	0% vs 20%	q
1	RRC		0.19	1	RRC	0 < 20	8.44**
	RBC		2.75		RBC	0 < 20	15.77**
	RTC	0 < 20	4.41**		RTC	0 < 20	7.30**
2	RRC		1.33	2	RRC	0 < 20	8.27**
	RBC		0.97		RBC	0 < 20	5.95**
	RTC	0 < 20	4.30**		RTC	0 < 20	8.14**
3	RRC		0.94	3	RRC	0 < 20	8.89**
	RBC		1.86		RBC	0 < 20	13.47**
	RTC		2.52		RTC	0 < 20	8.19**

** $p \leq .01$

TABLE 5c

Individual Comparisons (Newman-Keuls procedure) for Differences between Drive Levels at each Incentive for each Discrimination Task for each Trial Block seperately for Mean Running Speed on Inter Test Trials.

	0% Position				20% Position		
	HI vs MOD				HI vs MOD		
Day	Task		q	Day	Task		q
1	RRC	H > M	8.21**	1	RRC		1.61
	RBC	H > M	7.54**		RBC	H < M	2.88*
	RTC	H > M	6.26**		RTC	H > M	3.95**
2	RRC	H > M	7.48**	2	RRC		1.92
	RBC	H > M	7.71**		RBC	H < M	4.28**
	RTC	H > M	7.12**		RTC	H > M	3.52*
3	RRC	H > M	8.34**	3	RRC		1.98
	RBC	H > M	7.31**		RBC		1.98
	RTC	H > M	8.41**		RTC	H > M	3.88**

** $p \leq .01$

* $p \leq .05$

drive group separately indicated that all MOD animals ran significantly faster to the 20% position ($p < .01$). HI-RTC animals showed a similar pattern of responding, and during 2 of the 3 test days ran significantly faster to the 20% position ($p < .01$). HI-REC and HI-RRC animals showed no significant differential responding. Comparisons within each incentive position between HI and MOD animals trained in the same respective discrimination task found that HI animals ran significantly faster to the 0% position than MOD animals ($p < .01$). MOD-RBC animals ran significantly faster to the 20% position than HI-REC animals on the test day 1 and 2 ($p < .05$, and $p < .01$ respectively). The latter difference was reversed in the RTC group, in which HI animals revealed a significantly faster running speed to the 20% incentive than MOD animals on each of the 3 test days ($p < .01$ for blocks 1 and 3, $p < .05$ for block 2).

In summary, during the test phase MOD animals in all three discrimination task conditions and HI-RTC animals ran more quickly to the 20% incentive than to the 0% incentive. For the REC task MOD animals ran more quickly to the 20% incentive than HI animals. For the RTC task, however, HI animals ran more quickly than MOD animals to the 20% incentive. In all three discrimination tasks MOD animals showed much slower speed than HI animals to the 0% incentive.

Simultaneous incentive position test. Over the three test trial blocks animals received 12 trials during which both incentive position doors were unlocked and denoted by

S+. Thus, in the RRC task both sides of the decision chamber floor were rough and both doors black. For the RBC and RTC tasks the S+ (black doors, and rough floor sides, respectively) denoted both positions, while the irrelevant cue was presented randomly on one of the positions. Thus, except for the simultaneous presentation of S+ on both positions no other changes were introduced. For each animal the position of the incentives was kept the same as during discrimination training. Each trial block contained four such choice trials.

Observation of the individual subjects data revealed that choices were less varied in the MOD than in the HI drive animals in all discrimination task groups. MOD animals chose the 20% position four times per trial block, except in two cases where an animal made one choice (out of 12) to the 0% position. HI animals also showed a preference for the 20% position, however, the 0% position was chosen on some of the test trials. Only one HI animal (in the RBC task) preferred the 0% position on all trials. Three other animals (in RRC task) went to the 0% position for 3 or 4 trials in some of the trial blocks. In all other cases HI animals chose the 20% sucrose position for two or more times.

Two response criteria were employed to determine preference to the 0% or 20% position (Table 6, p. 65). The first criterion determined the number of animals within each drive x discrimination task group, which chose the 20% position for 75% or more of the test trials for each test day ($\geqslant 3$) and for total number of test trials ($\geqslant 9$). Using the Fisher's

TABLE 6

Number of Animals chosing the 20% Position at 75% or 100% Preference Criterion for each Test Day and for all Test Days combined

Drive	Task	Number of animals showing 75% or more preference for 20% position			
		Day 1	Day 2	Day 3	Total
HI	RRC	4	4	6	3
	RBC	6	7	7	7
	RTC	8	7	7	7
MOD	RRC	8	8	8	8
	RBC	8	8	8	8
	RTC	8	8	8	8

Drive	Task	Number of animals showing 100% preference for 20%			
		Day 1	Day 2	Day 3	Total
HI	RRC	2	2	4	1
	RBC	4	7	6	4
	RTC	7	5	6	3
MOD	RRC	8	7	8	7
	RBC	8	8	8	8
	RTC	7	8	8	7

exact probability test (Siegel, 1956), it was determined whether the number of 20% position choices differed between drive groups within each discrimination task. HI-RRC animals chose the 20% position on significantly fewer test trials than MOD-RRC animals on day 1 and 2, and over all days ($p < .05$). On the third day, however, no significant difference was found between HI and MOD-RRC animals. For the RBC and RTC tasks the difference between HI and MOD animals was not found significant on any of the days or total. Furthermore, under the 75% preference criterion significantly more MOD animals in each of the discrimination tasks preferred the 20% position to the 0% position on each day and over all test trials combined ($p < .01$, binomial tests). Under the HI drive condition significant greater preference for the 20% position was shown by HI-RTC animals on all three days and over total and by HI-RBC animals on day 2 and 3 and over total ($p < .05$). No preference was indicated in the HI-RRC group.

The second criterion determined the number of animals within each drive x discrimination task group, which chose the 20% position on each test trial per day (4) and over all choice trials (12). This most stringent preference measure noted thus 100% preference. The Fisher's exact probability test indicated that significantly less HI-RRC animals chose the 20% position for 100% at the time than MOD-RRC animals ($p < .05$). Significant drive differences were also found in the RBC task on day 1 and over all test trials ($p < .05$)

with 100% preference measure. No significant differences were found between HI and MOD-RTC animals. Under this criterion significantly more MOD animals in each discrimination task condition preferred the 20% position above the 0% position ($p < .05$). In the HI-RRC group less than half the animals preferred the 20% position for each day or over all test trials, a nonsignificant proportion. Similar results were found for the HI-RBC and HI-RTC groups, except on day 1 in which significantly more RTC animals ($p < .05$) and on day 2 in which significantly more RBC animals chose the 20% position ($p < .05$).

In summary, drive differences were smallest in the RTC task, in that MOD and HI animals did not differ in number of choices of the 20% position. In the RRC task, however, HI animals chose the 20% position on fewer trials than MOD-RRC animals. In the RBC task only for the 100% preference criterion MOD animals chose the 20% position more frequently than HI-RBC animals on some of the test days. However, in all three discrimination groups less HI animals showed total preference for the 20% than at the 75% preference criterion.

CHAPTER IV

Conclusions and Discussion

Rate of learning was faster in the groups which were trained in the RRC task, while the RTC animals required the largest number of trial blocks to reach learning criterion. Faster learning rates in groups which were presented with a redundant relevant cue problem (RRC task) have also been observed in several other studies (e.g. Warren, 1963; Restle, 1955). The addition of an irrelevant cue (as in the RBC and RTC task) has generally been shown to slow down the acquisition of a task (Lovejoy, 1968). Drive differences in rate of learning were observed in the RBC task only. MOD-RBC animals required more trials to criterion than HI-RBC animals. The latter finding is contrary to a study by Telegdy and Cohen (1971) in which it was found that drive level did not affect acquisition rate. However, the latter study did not employ differential incentives.

Errors made to incentive positions combined revealed similar differences between groups as the data for trials to criterion. However, drive and discrimination task affected the density of errors to each incentive position separately. MOD animals were expected to commit more errors when the S+ denoted the 0% position than when the 20% position was positive. Difference in error density, however, was only found for the MOD animals in the RBC and RTC task. Contrary

to the expectation the MOD-RRC animals made equal errors to either position. On basis of the distinctive cue at the beginning of the running response HI-RRC and HI-RTC animals were expected to respond in a similar manner as the MOD animals. However, none of the HI drive groups showed a difference in error density. Similar results were found in an earlier study (Cohen & Oostendorp, unpublished manuscript) in which HI drive animals displayed an equal number of errors to each position. MOD drive animals in the earlier study showed response differentiation similar to the MOD-RBC and MOD-RTC animals in the present study.

The prediction that MOD drive animals in each of the discrimination tasks would show a faster running speed to the high incentive position was validated. These results replicated the findings for moderately thirsty rats in the study by Cohen and Oostendorp (unpublished manuscript). Similarly, these results also support predictions based on Beck and Nash's (1969) differential approach arousal theory. The moderately thirsty animals showed greater response strength when presented with the S+ on the 20% sucrose position, than when only water reinforcement could be obtained.

The hypothesis that HI drive animals presented with a distinctive cue at the beginning of the running response, in the RRC and RTC task, would run faster to the 20% side was validated for the HI-RTC animals only. Greater response strength for sucrose over water in highly thirsty rats has not been found in other studies in which the incentive

presentation was interrupted and of short duration (e.g. Beck et al., 1972). The HI-RBC group showed the predicted nondifferential running speed to the two incentive positions. Thus, the latter group replicated the findings for the high drive animals in the Cohen and Oostendorp study (unpublished manuscipt). Support was also provided for findings in which thirsty rats showed equal response strength in bar pressing for any sucrose concentration and for water (e.g. Beck, 1963; Beck & Ellis, 1966). The HI-RRC animals also displayed a similar nondifferential running speed.

The results indicated an interaction effect between drive and incentive. HI and MOD water deprived animals showed a great difference in running speed to the water side and a small difference to the sucrose position. The interaction effect between drive and incentive was also observed in the study by Cohen and Oostendorp (unpublished manuscript). It has to be noted, however, that the interaction between thirst drive and sucrose incentive is in a reversed direction of what would be expected for food deprived animals and different sucrose concentrations. Hungry and moderately hungry, or satiated animals generally display a greater difference in running speed for the high incentive as shown by Beck and Austin (1973).

During the simultaneous incentive presentation in which both positions were denoted by the positive cue(s), position preference (at 75% criterion) was not affected differentially by drive level in the RBC and RTC tasks.

Contrary to the prediction, however, HI-RRC animals choose the 20% position fewer times than NOD drive animals. Hence, in the RRC task HI drive animals showed a similar response pattern as the thirsty rats in the study by Beck and Bidwell (in press). HI-RSC and HI-RTC animals did only differ with NOD drive animals in the same task when tested for complete preference. Thus, as was observed in the study by Cohen and Oostendorp (unpublished manuscript) drive only affected total preference to the sucrose solution, in that HI drive animals made some water position choices. According to Beck and Nash's (1969) approach arousal theory thirsty animals in all three discrimination tasks would have been expected to choose both position equally often.

The above findings seem to allow for some implications in relationship with other incentive approach arousal studies. In the present study the error density for each incentive position separately had been included as a measure of differential approach arousal. The measure had also been used in the study by Cohen and Oostendorp (unpublished manuscript). The findings revealed a similar effect of drive on error density and running speed, in that NOD animals made more errors and ran slower to the water side, while no effect in either of the measures was observed for HI drive animals. In the present study several groups committed a nonsignificant larger number of errors when the S+ was presented at the water side. The latter findings could have been interpreted as showing nondifferential approach

behavior to the two incentives. However, two of these groups, MOD-RRC and HI-RTC, showed a faster running speed to the 20% position. Furthermore, a clear preference for the sucrose side was exhibited in the simultaneous choice situation by these groups, as well as the HI-RBC group. Consistent response differentiation in all measures, however, was observed in the MOD-RBC and MOD-RTC animals. These findings appear to indicate that an error could be committed due to one of two reasons. Approach arousal for one of the positions might have been so low that the animal failed to attend to the S+ on that position. Or an error was made because the animal had not yet learned the discrimination task. The first assumption seems to support Pubols (1960) that rate of learning was retarded after the animals had learned to discriminate between the two incentives (MOD-RBC and MOD-RTC tasks). MOD animals in the RRC task apparently learned the simultaneous discrimination and successive incentive task at an equal rate. Errors in the latter group as well as in the HI drive group may have been committed due to incomplete acquisition of the discrimination task. These considerations suggest that error density is a confounded measure of approach arousal, which is affected by the type of discrimination task as well as by drive level.

Very few studies have indeed employed the error density measure in relationship with differential approach arousal. Dufort and Kimble (1956), however, used an incentive shift paradigm to test differences between errors for a high and

a low incentive. The rats were first presented with 20 experimenter corrected trials (two blocks of 10) in a brightness discrimination task in a runway. All animals (23 hr. food deprivation) received a 10% sucrose solution. The discrimination task had not been acquired after these first 20 trials. Following these trials the animals were divided into 4 groups which received one of four incentives, 20%, 10%, 5% sucrose, or an empty cup. Animals which continued to receive a 10% sucrose solution or which received the higher incentive were found to improve in learning performance. Animals which were switched to a low incentive, a 5% sucrose solution or an empty goal cup, increased the percentage of errors. Dufort and Kimble (1956), however, gave only four trial blocks after the reinforcement shift and it was not established whether the animals which received the 5% sucrose solution improved in performance after the initial decline. Running speed showed a similar shift in performance as the percentage of errors. The shift paradigm, however, did not require the animals to show differential approach arousal from one trial to the next as in the present study. Percentage of errors thus presented a measure of an approach arousal to a constant incentive while in the present study error density was expected to measure differential or non-differential approach arousal for two distinct stimulus-incentive associations.

In contrast with the error density measure, strength of the running response has been considered to be directly

related to the vigor of the consummatory response through mediation of the $r_g - s_g$ mechanism (Spence, 1956). The incentive value for water is very small for moderately thirsty rats. The weak vigor of the consummatory response was transferred onto the fractional anticipatory response which resulted in a slow running speed to the water position. Approach arousal to the sucrose side, however, was very strong. The difference in incentive value of water and sucrose is smaller and decay of differential incentive stimulus faster in highly thirsty rats (Beck & Nash, 1969). This was shown in the speeds of HI-RRC and HI-RBC animals. The HI-RTC animals, however, showed differential approach arousal. It might be speculated that the distinctive cue at the entrance of the decision chamber prevented decay in differential approach strength. The distinctive cue enhanced the conditioning of $r_g - s_g$'s of differential vigor. Location of the distinctive cue at the beginning of the running response in the RTC task indicated whether the sweet substance or water could be obtained, thus influencing the running speed. In the HI-RBC group the cue indicating which substance could be obtained might have only been observed by the animals after they had first approached the stimulus wall. For these animals then any differential approach occurred very close to the doors and could not have been reliably measured as differential speeds. HI-RBC animals, however, appeared to have learned to discriminate between the sweeter and the regular solution, just as the RTC animals. An incentive-position

association was acquired, as inferred from preferences to 20% incentive on free choice trials in HI rats.

The question remain as to why HI-RRC animals did not show any speed differences. They, as RTC animals, also were given an early texture cue. HI drive animals in a study by Telegdy and Cohen (1971) were found to learn a RRC task at a similar rate as MOD drive animals. The test on cue utilization, however, revealed that more MOD drive animals than HI drive animals were able to utilize both cues. This study supported the hypothesis proposed by Easterbrook (1959) of an inverse relationship between drive level and span of attention or cue utilization. Highly aroused organisms appear to select one effective cue, i.e. a cue which predicts reinforcement at a very high probability. Moderately aroused organisms have a wider span of attention and may select different cues on subsequent trials. It can be suggested that the HI-RRC animals in the present study selected one of the relevant dimensions. From their similar responding as RRC animals, it would appear that HI-RRC animals utilized the further brightness cues and ignored the earlier texture cues. In their theory of selective attention Sutherland and Mackintosh (1971) postulate that the more an organism attends to one relevant dimension, the less can be learned about another dimension. In the study by Telegdy and Cohen (1970) the brightness cue on the goal chamber doors, in the same apparatus as for the present study, was found to be a very salient cue. Hence, it might be speculated that the HI-RRC

animals did not utilize the texture cue. Therefore, conditioning of the $r_g - s_g$'s of differential strength was not present in the HI-RRC group.

HI-RRC and HI-RBC animals showed equal running speed to both incentive positions. In the simultaneous incentive presentation the HI-RRC animals similarly revealed no preference for the sucrose position. HI-RBC animals, however, choose the sucrose position on more test trials than the water side. In view of the selective attention theory the redundancy of cues in the RRC task not only prevented the animals from employing the texture cue, but also from acquiring incentive-position association. Although HI-RRC animals may be using the brightness cue as the dominant dimension, the presence of a relevant texture cue can also be said to share in some of the attention of the animal. Therefore, less of the "attentional pie" can be used to attend to the incentive-position. For NOD animals this is not so drastic a problem since they have a greater field or span of attention. For HI animals, however, they are already operating with a limited field attention, that the addition of redundant relevant cues might greatly affect (i.e. diminish) their ability to attend to incentive-position. The addition of an irrelevant cue, however, does not decrease the amount of the attentional pie as described by Thomas (1970) to the incentive-position cues. Subsequently, the HI-RBC animals had learned the incentive-position association to such a degree that the cue could be utilized in

simultaneous but not in successive incentive presentations. Jenkins and Sainsbury (1969) provided evidence that animals learn a simultaneous discrimination task at a faster rate than a successive discrimination task. When a task includes both, simultaneous discrimination learning will precede utilization of successively presented dimensions. The increase in number of choices for the sucrose position in the HI-RRC group seems to indicate that learning of the incentive-position association was still taking place during the test trials. The difference in free choice preference between MOD and HI-RRC animals can not be attributed to different rates of discrimination learning. Both drive level groups learned the RRC task in very few errors and trial blocks.

HI-RRC animals behaved in a manner similar to the highly water deprived animals in the study by Beck and Bidwell (in press). The animals in the latter study were not required to learn a discrimination task and cue utilization was therefore not enhanced. Sutherland (1966) produced evidence that animals, which were reinforced 50% of the time for a correct choice, learned more about the presented cues than animals which were reinforced 100% of the time. Water had a very low reinforcement value for the food deprived animals in the Beck and Bidwell (in press) study as well as for the MOD animals in the present study. Thus MOD drive RRC animals may be considered to have received a type of partial reinforcement, i.e. water not being as reinforcing as sucrose on the successive presentations. HI-RRC animals can be considered

to have received reinforcement similar to Sutherland's 100% schedule, i.e. water being almost as reinforcing as sucrose. Therefore, in the RRC condition HI animals would be expected to learn less about the relevant cue. In this way the value of incentive could be the mediating variable to have affected the amount of cue utilization in this study or in Telegdy and Cohen's study (1971). In that study, according Sutherland's position (1966), moderate drive animals may not have always responded to the reinforcement.

The results of the present study seem to indicate that incentive-stimulus associations are formed more easily when distinctive cues are available and when the animal is required to increase the "attentional pie" during the performance of the instrumental response. Shifting of incentive positions from day to day in the study by Beck et al. (1972) may have prevented differential approach arousal in the water deprived animals. Due to the small difference in incentive stimulus traces for the highly water deprived rats distinctive cues need to be very salient. Incentive stimulus traces in MOD animals show greater difference and thus cues need not be as salient in order to evoke an incentive association.

In contrast with the study by Beck and Bidwell (in press) the present study employed greater incentive differences (8% vs water, and 20% vs water respectively). According to Beck and Nash (1969) differential approach arousal would be expected to be smaller when utilizing two incentives which show only a small incentive separation. Whereas, the

reinforcement value of water is very high for water deprived animals, a very wide incentive separation may be necessary to show a sucrose preference in highly thirsty rats. In the study by Beck and Bidwell (in press) the relatively small difference in incentives might have prevented differential approach arousal in the water deprived animals. The obtained preference in the present study has been attributed to differences in procedure such as discrimination training and cue salience as discussed above. Another major variable, however, might have been the much larger incentive separation.

The present study allowed the animals 10 seconds of free drinking time, while Beck and Bidwell (in press) only provided 3 drops of each solution in the goal box. Perhaps animals in the present study may have had a greater opportunity to counteract tissue dehydration and thus might have increased preference for sweeter solution. It should be noted that Cohen and Tokieda (1972) found that highly water deprived animals would reverse their water preference to sucrose preference after free access to tap water for 5 min. or 14 gm. For the 3 min. or 7 gm. prewatering values indifferent behavior to the sucrose and water solutions was observed. The present study, however, allowed for much less prewatering before any test trial. Under such conditions it is difficult to posit that enough tissue hydration occurred to allow for the observed sucrose preference. This does not mean that tissue dehydration played no factor in preferences

by HI animals, since only those rats chose water on some of the test trials.

Implications for further research

The difference in rate of acquisition of the discrimination task allowed some of the groups to obtain more experience with the successive incentive presentation than other groups. Each of the discrimination groups should therefore be tested after an equal number of trial blocks, independent of performance in the discrimination task. It could then be observed whether the lack of experience with the incentives or the restricted attention span influenced the choice behavior in the HI-RRC animals.

Furthermore, it was hypothesized that the discriminative cue at the beginning of the decision chamber enhanced differential approach arousal in comparison to the brightness cues at the end of the decision chamber. Two groups of highly water deprived animals could be tested on a single cue discrimination task. One group would be trained with a texture cue, the other with a brightness cue in a similar incentive discrimination task as the present study. To test the strength of the differential approach arousal in the groups the 0% position could be made S- and the 20% position S+. The texture cue group would be expected to make less errors, because a stronger approach arousal had already been obtained during the previous task. No such facilitation could be expected in the brightness cue group.

Further research employing different sucrose concentrations

could be done to determine the effect of incentive separation on differential approach arousal in water deprived rats. Therefore, different groups of animals should be provided with incentives which show either a large or a small difference in sucrose concentration. By utilizing different discrimination tasks the study might clarify the relationship between apparatus cues, conditioning of r_g - s_g's of differential strength, and mediation of incentive motivation onto response strength. Furthermore, it may be hypothesized that incentive discrimination becomes also more difficult for 40D animals when small incentive separations are used. Subsequently, utilization of apparatus cues might also increase for moderately thirsty animals when presented with similar sucrose concentrations.

Although it remains difficult to test the effect of hypothetical mechanisms such as the fractional anticipatory response, the present study supports Spence's theory that the conditioning of the r_g to apparatus cues plays an important role in the transfer of incentive motivation onto instrumental responses.

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APPENDIX A

Mean Number of Errors on the 0% and 20% Position

(Standard Deviations in Parentheses)

	RRC	RBC	RTC
HI Drive			
0%	10.75 (3.15)	16.75 (4.39	26.13 (19.78)
20%	10.75 (5.50)	11.25 (5.47)	22.88 (11.47)
MOD Drive			
0%	15.38 (6.07)	28.63 (14.86)	31.75 (9.79)
20%	10.00 (6.43)	9.38 (4.49)	15.63 (6.72)

APPENDIX B

Means for Daily Running Speed over five Discrimination Trial Blocks to 0% and 20% Position for Drive x Discrimination Task Groups (Standard Deviations in Parentheses)

HI Drive

Trial Block		RRC	RBC	RTC
1	0%	0.87 (0.33)	0.96 (0.25)	0.73 (0.13)
	20%	0.95 (0.34)	1.09 (0.25)	0.94 (0.21)
2	0%	1.06 (0.39)	1.01 (0.30)	0.77 (0.13)
	20%	0.99 (0.36)	1.06 (0.28)	0.99 (0.27)
3	0%	1.02 (0.28)	1.09 (0.27)	0.77 (0.06)
	20%	0.98 (0.29)	1.16 (0.17)	0.98 (0.15)
4	0%	1.07 (0.41)	1.02 (0.31)	0.80 (0.19)
	20%	1.09 (0.42)	1.13 (0.14)	0.99 (0.26)
5	0%	1.03 (0.30)	1.08 (0.21)	0.81 (0.21)
	20%	1.20 (0.43)	1.17 (0.13)	1.06 (0.24)

MOD Drive

Trial Block		RRC	RBC	RTC
1	0%	0.41 (0.18)	0.59 (0.45)	0.35 (0.19)
	20%	0.86 (0.29)	1.29 (0.37)	0.76 (0.20)
2	0%	0.35 (0.29)	0.52 (0.47)	0.34 (0.21)
	20%	0.95 (0.26)	1.41 (0.45)	0.76 (0.32)
3	0%	0.45 (0.27)	0.62 (0.40)	0.36 (0.19)
	20%	0.98 (0.28)	1.40 (0.42)	0.80 (0.34)
4	0%	0.60 (0.38)	0.55 (0.28)	0.36 (0.18)
	20%	1.02 (0.27)	1.42 (0.50)	0.78 (0.30)
5	0%	0.60 (0.30)	0.53 (0.35)	0.40 (0.18)
	20%	0.99 (0.17)	1.41 (0.44)	0.82 (0.28)

APPENDIX C

Means for Running Speed on First Trials over five Discrimination Trial Blocks to 0% and 20% Positions (Standard Deviations in Parentheses)

HI Drive

Trial Block		RRC	RBC	RTC
1	0%	0.76 (0.31)	0.86 (0.23)	0.65 (0.19)
	20%	0.86 (0.33)	1.02 (0.33)	0.86 (0.19)
2	0%	1.04 (0.39)	0.96 (0.31)	0.73 (0.16)
	20%	0.97 (0.30)	0.99 (0.26)	0.94 (0.32)
3	0%	0.97 (0.28)	1.05 (0.25)	0.73 (0.09)
	20%	0.88 (0.15)	1.13 (0.12)	0.88 (0.16)
4	0%	1.04 (0.38)	0.97 (0.33)	0.75 (0.18)
	20%	1.03 (0.44)	1.03 (0.20)	0.95 (0.30)
5	0%	0.95 (0.29)	1.16 (0.34)	0.83 (0.26)
	20%	1.14 (0.42)	1.10 (0.19)	0.99 (0.20)

MOD Drive

Trial Block		RRC	RBC	RTC
1	0%	0.34 (0.13)	0.56 (0.35)	0.31 (0.20)
	20%	0.74 (0.32)	1.18 (0.35)	0.70 (0.19)
2	0%	0.30 (0.26)	0.51 (0.50)	0.33 (0.24)
	20%	0.91 (0.24)	1.28 (0.57)	0.67 (0.26)
3	0%	0.47 (0.29)	0.59 (0.36)	0.40 (0.20)
	20%	0.91 (0.28)	1.30 (0.52)	0.77 (0.35)
4	0%	0.57 (0.39)	0.53 (0.26)	0.38 (0.19)
	20%	0.94 (0.34)	1.35 (0.52)	0.69 (0.27)
5	0%	0.57 (0.25)	0.54 (0.43)	0.32 (0.21)
	20%	0.92 (0.28)	1.31 (0.39)	0.77 (0.28)

APPENDIX D

Means for Running Speed on Inter Test Trials for three Test Trial Blocks to 0% and 20% Position (Standard Deviation in Parentheses)

HI Drive

Trial Block		RRC	RBC	RTC
1	0%	1.13 (0.38)	1.01 (0.33)	0.84 (0.25)
	20%	1.14 (0.44)	1.19 (0.19)	1.12 (0.28)
2	0%	1.12 (0.35)	1.08 (0.31)	0.89 (0.13)
	20%	1.20 (0.37)	1.14 (0.18)	1.17 (0.28)
3	0%	1.20 (0.27)	1.05 (0.28)	1.02 (0.12)
	20%	1.26 (0.39)	1.17 (0.21)	1.19 (0.25)

MOD Drive

Trial Block		RRC	RBC	RTC
1	0%	0.47 (0.24)	0.41 (0.17)	0.34 (0.19)
	20%	1.01 (0.31)	1.42 (0.34)	0.81 (0.18)
2	0%	0.52 (0.44)	0.46 (0.25)	0.32 (0.18)
	20%	1.05 (0.43)	1.49 (0.29)	0.84 (0.42)
3	0%	0.53 (0.43)	0.47 (0.27)	0.35 (0.22)
	20%	1.10 (0.40)	1.33 (0.28)	0.88 (0.29)

APPENDIX E

Number of Choices of the 20% Sucrose Position on each of the Test Sessions by Individual Animals

RRC Discrimination Task

HI Drive				MOD Drive			
Animal no	Day 1	Day 2	Day 3	Animal no	Day 1	Day 2	Day 3
1	4	4	4	9	4	4	4
2	3	0	1	10	4	4	4
3	1	4	3	11	4	4	4
4	2	0	1	12	4	4	4
5	2	2	4	13	4	4	4
6	2	3	3	14	4	4	4
7	3	2	4	15	4	3	4
8	4	3	4	16	4	4	4

RBC Discrimination Task

HI Drive				MOD Drive			
Animal no	Day 1	Day 2	Day 3	Animal no	Day 1	Day 2	Day 3
17	4	4	4	25	4	4	4
18	3	4	4	26	4	4	4
19	4	4	4	27	4	4	4
20	4	4	4	28	4	4	4
21	0	0	0	29	4	4	4
22	2	4	4	30	4	4	4
23	4	4	4	31	4	4	4
24	3	4	3	32	4	4	4

APPENDIX E (continued)

Number of Choices of the 20% Sucrose Position

on each of the Test Sessions

by Individual Animals

RTC Discrimination Task

HI Drive				MOD Drive			
Animal no	Day 1	Day 2	Day 3	Animal no	Day 1	Day 2	Day 3
33	4	4	4	41	4	4	4
34	4	3	4	42	3	4	4
35	4	4	4	43	4	4	4
36	4	4	3	44	4	4	4
37	3	4	4	45	4	4	4
38	3	2	2	46	4	4	4
39	4	4	4	47	4	4	4
40	4	3	4	48	4	4	4

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